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EVALUATION OF PCB DESTRUCTION EFFICIENCY IN AN INDUSTRIAL BOILER

by

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16. ABSTRACT The report describes the evaluation program undertaken to determine the polychlorinated biphenyl (PCB) destruction efficiency during a May 1980 verification co-firing of waste oil containing approximately 500 ppm of PCBs, in accordance with applicable state and federal regulations, in a high-efficiency industrial boiler owned and operated by General Motors Corporation at Bay City, MI. Also investigated was the environmental and workplace impact which occurs during the handling and combustion of PCB-contaminated waste oils. (According to EPA's final ruling on the disposal of PCBs, waste oils containing PCBs in the 50-500 ppm range can be fired with fuel oil and burned in a high-efficiency industrial boiler.) No PCBs were detected in the stack gas within the detection limits of the sampling and analytical techniques used. Data collected during the verification burn indicate that, by following the equipment and performance requirements given in EPA's final PCB rule (44, Federal Register, 31545, May 31, 1979), at least 99.9% destruction efficiency of PCBs can be achieved by high efficiency boilers. Furthermore, monitoring of the downwind ambient air, the workplace environment, and employee blood levels has indicated that PCB destruction can be conducted with no measurable adverse effect on either the workplace environment or the external environment.

17. KEY WORDS AND DOCUMENT ANALYSIS

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ABSTRACT

According to EPA's final ruling on the disposal of polychlorinated biphenyls (PCBs), waste oils which contain PCBs in the range 50-500 parts per million (ppm) can be fired with fuel oil and burned in a high efficiency industrial boiler. In May 1980, waste oil containing approximately 500 ppm of PCBs was co-fired in accordance with applicable state and federal regulations. This combustion took place in a high efficiency industrial boiler owned and operated by General Motors Corporation at Bay City, Michigan. This report describes the evaluation program which was undertaken to document the PCB destruction efficiency which occurred during the verification burn. Also investigated was the environmental and the workplace impact which occurs during the handling and combustion of PCB-contaminated waste oils.

No PCBs were detected in the stack gas within the detection limits of the sampling and analytical techniques used. The data collected during this verification burn indicate that, by following the equipment and performance requirements stated in EPA's PCB regulations (40 CFR 761), the 99.9 percent destruction efficiency requirement implied by the regulation can be achieved by high efficiency (industrial power) boilers. Furthermore, monitoring of the downwind ambient air, the workplace environment, and employee blood levels has indicated that PCB destruction can be conducted with no measurable effect on either the workplace environment or the external environment.

This report was submitted in fulfillment of Contract 68-02-3168, Work Assignment No. 9 by GCA/Technology Division under the sponsorship of the U.S. Environmental Protection Agency. This report covers the period of January 29, 1980 to October 31, 1980, and work was completed as of October 31, 1980.

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LIST OF ABBREVIATIONS

aq -- aqueous
Btu -- British thermal unit
CO -- carbon monoxide
CO_2 -- carbon dioxide
DIG -- distilled in glass
dscf -- dry standard cubic foot
dscm -- dry standard cubic meters
g -- gram(s)
gr -- grain(s)
GC/ECD -- gas chromatograph/electron capture detector
GC/MS -- gas chromatograph/mass spectrometer
gpm -- gallons per minute
HCl -- hydrogen chloride
kg -- kilograms, 10^3 gram(s)
lb/hr -- pounds per hour
m/e -- mass to charge ratio
m^3 -- cubic meter
mg -- milligram(s), 10^{-3} gram
Mlb/hr -- thousand pounds per hour
mph -- miles per hour
ng -- nanogram(s), 10^{-9} gram
O_2 -- oxygen
PCB -- polychlorinated biphenyl
ppb -- parts per billion
ppm -- parts per million
psig -- pounds per square inch gauge pressure
QA/QC -- quality assurance/quality control
TCO -- total chromatographable organic
THC -- total hydrocarbons
μg -- microgram(s), 10^{-6} gram
VMSTD -- flue gas volume, corrected to standard conditions, through dry gas meter
w.c. -- water column

SECTION 1

INTRODUCTION

BACKGROUND

In May 1980, waste oil contaminated with polychlorinated biphenyl (PCB) was combusted by Chevrolet Motor Division of General Motors at Bay City, Michigan in a high efficiency industrial boiler. The "burn" was conducted in conformance with the conditions established by the U.S. Environmental Protection Agency for PCB destruction in high efficiency boilers (40 CFR 761) and applicable state and local regulations. Federal regulations state that waste oil containing PCBs in the range of 50 to 500 parts per million (ppm) can be disposed of in a high efficiency boiler provided that:

- The boiler is rated at a minimum of 50 million Btu/hr.
- If the boiler uses natural gas or oil as the primary fuel, the carbon monoxide concentration in the stack is 50 ppm or less, and the excess oxygen is at least three (3) percent when PCBs are being burned;
- The waste does not comprise more than 10 percent (on a volume basis) of the total fuel feed rate;
- The waste fluid is not fed into the boiler unless the boiler is operating at its normal operating temperature (this prohibits feeding these fluids during either start up or shut down operations);
- The owner or operator of the boiler continuously monitors and records the carbon monoxide concentration and excess oxygen percentage in the stack gas while burning waste fluid.
- The primary fuel feed rate, waste fluid feed rate, and total quantities of both primary fuel and waste fluid fed to the boiler are measured and recorded at regular intervals of no longer than 15 minutes while burning waste fluid.
- The carbon monoxide concentration and the excess oxygen percentage are checked at least once every hour that waste fluid is burned. If either measurement falls outside the criteria specified in this rule, the flow of waste fluid to the boiler shall be stopped immediately.

The PCB burn was monitored by GCA Corporation under contract to the U.S. Environmental Protection Agency, by the Michigan Department of Natural Resources, and by General Motors in order to ensure conduct of the burn in accordance with governmental guidelines and in order to document the PCB destruction efficiency of the burn.

Operating plans (test plans) were developed by GCA Corporation and General Motors Corporation to ensure definition and coordination of responsibilities during the burn and to ensure the use of consistent sampling and analysis procedures during and subsequent to the burn.

Measurements of PCB concentrations in the waste oil feed and in the combustion exhaust gases were made to establish the PCB destruction efficiency. Combustion parameters (CO, O_2) were monitored to evaluate the boiler performance and to establish compliance with federal regulations governing the burn. Measurements were also made for PCB concentrations in the ambient and in-plant air and in workers' bloodstreams before, during, and after the burn in order to evaluate the environmental effect of the burn.

This report documents the results of the PCB destruction test burn at Bay City, Michigan, and describes the procedures used to acquire and assess the supporting data.

GCA TEST PROGRAM

The GCA test program provided protocol to conduct sampling and analysis of stack emissions and ambient air quality data. GCA conducted stack tests using an EPA Method 5 sampling train (40 CFR 60) modified specifically for capturing PCBs, as well as a second train modified to capture organic compounds and chlorinated hydrocarbons which could be combustion by-products. Simultaneously with the stack testing, GCA operated four ambient air monitors --one upwind and three downwind--to assess the impact of the verification burn on ambient PCB concentrations.

Three separate PCB tests were conducted with the boiler operating under normal load conditions. The usual boiler fuel, No. 6 fuel oil, was co-fired with 10 percent waste oil prepared to contain 500 ppm PCB; hence, the PCB concentration in the fuel being burned was approximately 50 ppm. In order to provide background data on emissions from the boiler, 1 day of testing was also conducted with No. 6 fuel oil only.

Extensive background information for the test burn is provided in the appendices of this report. These appendices include: operating parameters on all analytical equipment employed (Appendix A); work plan for the overall test effort (Appendix B), the air sampling analysis (Appendix C), the evaluation of PCBs in solid materials (Appendix D), and the analysis of PCB waste oil (Appendix E); measurement data on the boiler (Appendix F), the PCB waste oil (Appendices G, H, I), in-plant monitoring (Appendix J), boiler residue (Appendix K), blood chemistry (Appendix L), and stack test measurements (Appendix M), discussions of the fuel oil data (Appendix N), a log of significant actions (Appendix O), operation problems encountered with the waste oil supply (Appendix P), the premature termination of the third PCB run (Appendix Q), and data interpretation using standard statistical techniques (Appendix R).

Collectively, these appendices serve to augment and clarify the various aspects of the program described in the body of the report.

SECTION 2

RESULTS

PCB DESTRUCTION EFFICIENCY

Destruction efficiency test results presented in Table 1 indicate that at least a 99.99 percent PCB destruction efficiency was achieved during the test burn. This is significantly greater than the 99.9 percent destruction efficiency expected by EPA's PCB regulation. The actual destruction may be greater than that stated because the calculated destruction was limited by the detection sensitivity of the sampling and analytical techniques used in this project. The range in PCB inlet concentrations shown in Table 1 results from the uncertainties inherent in the analytical techniques used to measure PCBs. This uncertainty is discussed in more detail in the subsection entitled "PCB Fuel Concentrations."

The destruction efficiency determination is based on a mass balance of PCBs into and out of the boiler. Calculated PCB emission rates are presented in Table 2. Because quantities of PCB in the stack gases were below detectable levels, PCB out in milligrams per minute (mg/min) had to be expressed as quantities less than (<) an emission rate calculated at the detectable level.

DIBENZOFURAN/DIOXIN EMISSIONS

Concurrent with sampling for PCBs, a second Modified EPA Method 5 sampling train was used to collect organic combustion products emitted during the PCB burn. Analyses for chlorinated dibenzofurans and dioxins were undertaken. This train was operated simultaneoulsy with the PCB sampling train during two of three PCB burns and during the burning of uncontaminated No. 6 fuel oil. These sampling trains are discussed in detail in Section 4, "Sampling Procedures." As with PCB stack samples, all analyses were performed at the GCA laboratory.

The results of the analysis of stack samples for dibenzofurans and dioxins are shown in Table 3. The stack gas particulate and the XAD-2 resin (used to trap organic vapor) were independently analyzed for organic combustion products. No dioxin or dibenzofuran was detected in these samples at the limits of detectability.

IN-PLANT PCB CONCENTRATIONS

During the verification burn and the 1-day background burn, 42 tests were conducted by GM to measure employee workplace exposure to PCB. The tests were conducted by the GM Industrial Hygiene Department using modified sampling and

TABLE 1. DESTRUCTION EFFICIENCY OF PCB

Run number	Test day	PCB in fuel[a] concentration range (mg/kg)	PCB[b] in (mg/min)	PCB out (mg/min)	PCB[c] destruction efficiency (%)
PCB-2	2	34-72	480-1000	$<5.8 \times 10^{-2}$	>99.99[d]
PCB-3	3	34-76	480-1100	$<5.6 \times 10^{-2}$	>99.99[d]
PCB-4	3	34-76	480-1100	$<5.6 \times 10^{-2}$	>99.99[d]

Note: Density of 1:10 Dilution of Waste Oil: No. 6 Fuel Oil is 3.43 kg/gal.

[a] Based on GM and GCA interlaboratory results.

[b] Fuel combustion rate: 3.43 kg/gal x 4 gal/min fuel flow = 14 kg/min.

[c] Percent destruction $100 \left[\frac{\text{PCB in} - \text{PCB out}}{\text{PCB in}}\right]$

[d] This assumes 100 percent sample collection efficiency.

TABLE 2. STACK EMISSION RATE OF PCB

Run number	Test day	Gas volume sampled (DSCM)[a]	Aroclor 1242 detected (mg)[b]	Stack gas concentration of Aroclor 1242 (mg/m^3)	Stack flow (DSCMM)[c]	PCB out (mg/min)
PCB-1[d]	1	4.898	<0.001	$<2.0 \times 10^{-4}$	274	$<5.6 \times 10^{-2}$
PCB-2	2	5.380	<0.001	$<1.9 \times 10^{-4}$	307	$<5.8 \times 10^{-2}$
PCB-3	3	5.785	<0.001	$<1.7 \times 10^{-4}$	328	$<5.6 \times 10^{-2}$
PCB-4	3	5.964	<0.001	$<1.7 \times 10^{-4}$	346	$<5.6 \times 10^{-2}$
PCB-5	4	3.207	NA[e]	NA[e]	264	-

[a] Dry standard cubic meters.

[b] Based on GC/ECD results (<1.0 μg Aroclor 1242/extract).

[c] Dry standard cubic meters/min.

[d] This was a run to measure background levels of PCBs in the stack gas. No PCB contaminated waste oil was burned during this run.

[e] NA - Sample extract was inadvertently spilled during analysis sequence. This loss was not integral to calculating destruction efficiency with confidence because of redundant sampling.

TABLE 3. STACK EMISSIONS DATA FOR DIBENZOFURANS AND DIOXINS

Run number	Test day	Gas volume sampled (DSCM)[a]	Weight in particulate extract (mg)	Concentration in particulates (mg/m^3)[b]	Weight in resin extract (mg)	Concentration in resin extract (mg/m^3)	Detection limit (µg/ml extract)
M5-1[c]	1	4.808	$<1.0 \times 10^{-3}$	$<2.1 \times 10^{-4}$	$<8.5 \times 10^{-4}$	$<1.8 \times 10^{-4}$	0.5
M5-2	2	5.446	$<5.0 \times 10^{-4}$	$<9.2 \times 10^{-5}$	$<8.5 \times 10^{-4}$	$<1.6 \times 10^{-4}$	0.5
M5-3	4[d]	3.290	$<5.0 \times 10^{-4}$	$<1.5 \times 10^{-4}$	$<8.5 \times 10^{-4}$	$<2.6 \times 10^{-4}$	0.5

[a] Dry standard cubic meters.

[b] M5-1 Particulate is 50 percent aliquot, M5-2 and M5-3 are 100 percent aliquot.

[c] This was a run to measure background levels of dibenzofuran and dioxins in the stack gas. No PCB-contaminated waste oil was burned during this run.

[d] No dibenzofuran or dioxin data were taken on day 3. On day 3 two trains were run simultaneously for PCB sampling to test reproducibility. Dioxin and dibenzofuran sampling was resumed on day 4.

analysis techniques recommended for the isomers of PCB as specified in Physical and Chemical Analytical Method--Number 253 of the National Institute of Occupational Safety and Health (NIOSH) Manual.[1] Sixteen of the tests were made in the breathing zone of the boiler operators. The PCB detection limit for these samples was on the order of 50 $\mu g/m^3$. The remaining 26 were general conditions tests made at two selected sites in the powerhouse. The PCB detection limit for these samples was approximately 10 $\mu g/m^3$. Samples were analyzed for PCB by GM's Industrial Hygiene Department. The sampling procedures followed and equipment used are more fully described in Appendix B. Breathing zone and powerhouse monitoring results are presented in Appendix J. All tests showed nondetectable levels of PCB. This indicates that concentrations were less than the recommended Occupational Safety and Health Administration (OSHA) 8-hour levels of 1 mg/m^3 and 0.5 mg/m^3 for Aroclor 1242 and Aroclor 1254, respectively (29 CFR 1910.1).

PCB BLOOD CHEMISTRY LEVELS

Testing was performed on GM powerhouse operators to measure blood PCB levels before and after the verification burn. Preburn levels ranged from 7 to 36 parts per billion (ppb) with an average of 18.0 parts per billion. Post-burn levels were 5.4 to 40 ppb with an average of 18.6 ppb. Within the limits of accuracy of this testing, the pre- and post-burn samples showed no significant changes in blood levels of PCB. These blood chemistry results are reported in Appendix L.

A comparison study was performed by GM on 39 office workers who presumably would have no work association with PCB. The study is cited in Appendix L. It showed that: those who eat in excess of 8 oz of Great Lakes fish per week have in their blood a PCB range of 4 to 71 parts per billion and an average of 23.5 parts per billion. Those who average less than 8 oz of Great Lakes fish per week have a range of 3.4 to 50.3 parts per billion and an average of 18.03 parts per billion.

The powerhouse employees therefore showed blood levels comparable to those office employees with the least exposure to environmental PCB.

BOILER PCB RESIDUAL LEVELS

Before and after the PCB verification burn, scrapings from various points inside the boiler were taken to determine PCB residue. These residual scrapings were analyzed by the GM Industrial Hygiene Department to determine the presence of PCBs. The test method employed for this analysis is discussed in Appendix D and the results are reported in Appendix K.

The analytical technique used for residue analysis was sensitive to PCB concentrations in the parts per billion (ppb) range. Yet, PCB concentrations could be detected in only one of the 24 preburn residue samples and only 8 of the 20 post-burn samples. The residual level of PCBs for all but one of the samples was substantially less than 0.1 parts per million (ppm). The sole exception was the oil burner tip residue, where the PCB concentration was in the 0.8 ppm range. These results indicate that there was no significant level of PCBs within the boiler, either before or after the PCB test burn.

PCB FUEL CONCENTRATIONS

Fuel samples were analyzed for PCB by GM and GCA laboratories by using a gas chromatograph with an electron capture detector (GC/ECD). Sampling and analysis procedures followed by GCA are detailed in Appendix N; those followed by GM are listed in Appendix E. The PCB concentrations reported by each laboratory are listed in Table 4. The variation demonstrated in Table 4 is not unusual with interlaboratory analysis of a complex mixture such as PCBs. An audit was performed at the GM and GCA laboratories to verify that procedures used on fuel samples were analytically sound. The results of the audit verified the comparability of the GCA and GM analyses.[2]

TABLE 4. PCB CONCENTRATIONS IN FUEL

Sample ID	GM results mg/kg)	GCA results mg/kg)
Spiked Waste Oil	496	750
Fuel Feed Run PCB-2	34	72
Fuel Feed Runs PCB-3 & 4	34	76
Fuel Feed Run PCB-5	34	88

The range in concentration, as reported above, was further investigated by an independent EPA laboratory which analyzed split samples from GCA's spiked waste oil and GM's spiked waste oil. The EPA laboratory reported values of 614 and 640 mg/kg for aliquots of the GM and GCA samples, respectively. These values are intermediate to the GCA and GM values and within the range of expected agreement for analysis of a complex mixture containing PCBs.

AMBIENT PCB CONCENTRATIONS

The ambient monitoring network was designed to measure PCB concentrations in the ambient air on plant property and in the immediate populated area downwind of the stack during the test burns. Meteorological conditions on the date of each burn were used to position the monitors in areas on the plant property where maximum downwash from the stack effluent was predicted. In this way, PCB background levels, increases in concentrations of PCBs, and PCB concentration in the nearest populated area which could have been exposed to PCBs as a result of the test burn were measured.

Ambient sampling occurred on the same days as the stack sampling; i.e., 1 day was specified as a background burn (No. 6 fuel oil only) followed by 3 days of burning a combination of No. 6 fuel oil and PCB-contaminated waste oil. The monitors were operated in a synchronized manner with the collection of stack gas samples.

Four runs, each 3 hours in duration, comprised the 12-hour ambient monitoring sample period. The four runs were: a preburn, a post-burn, and two runs during the burning of waste oil. Testing coordination was designed so that no waste oil would enter the boiler until the 3-hour preburn run was complete. The post-burn run was not started until a time lag, derived from prevailing wind velocity, sufficient to ensure that effluent from the stack would have passed by the monitors, had occurred.

Analysis of ambient samples was performed at the GCA laboratory. Results showed that ambient concentrations of PCBs at the downwind test sites were less than the upwind concentrations by factors which ranged between 200 to 400 percent. This indicates emissions from the test burn did not increase the ambient air loading of PCBs in any significant manner. The ambient tests results are shown in Table 5.

TABLE 5. RESULTS OF AMBIENT PCB ANALYSIS (μg/m^3)[a]

Site identification	Test day 1	2	3	4
UPWIND-Site 1[b]	0.19	0.35	0.39	0.12
DOWNWIND-(preburn)-Site 2[c]	1.4	0.16	0.043	0.063
DOWNWIND-(burn)-Site 2[d]	0.43	0.084	0.019	0.13
DOWNWIND-(post-burn)-Site 2[c]	0.050	0.24	0.019	Not sampled
DOWNWIND-(preburn)-Site 3[c]	0.50	0.092	0.017	0.024
DOWNWIND-(burn)-Site 3[d]	0.29	0.082	0.055	0.026
DOWNWIND-(post-burn)-Site 3[c]	0.015	0.015	0.019	Not sampled
POPULATED AREA - Site 4[b]	0.063	0.067	0.028	0.051

[a] Aroclor 1242.

[b] Twelve-hour sampling period.

[c] Three-hour sampling period.

[d] Six-hour sampling period.

Section 4, Sampling Procedures, provides a further description of the protocols and equipment used in conducting the ambient air sampling for PCBs. Section 6, Air Quality Model Calculations, describes and presents the modeling results used to locate the ambient air quality samplers.

DATA INTERPRETATION

A statistical analysis of the measured ambient PCB data was undertaken to determine the significance, if any, of plant contributions to background PCB levels. A paired t-test, using ambient PCB monitoring data collected at each of the four monitoring stations before, during and after each PCB burn, was employed for this analysis. The t-test results concluded that there had been no apparent increase in PCB levels in downwind or nearby residential areas due to any of the PCB burns.

Analysis of the stack PCB emissions was also to be conducted to determine the statistical validity of the PCB destruction efficiencies achieved. However test results for the third burn day were lost, and there were no measurable PCB concentrations from which to determine variability on each of the remaining 2 days. Therefore the planned statistical test could not be meaningfully applied to the test data. A more thorough description of the statistical methods employed in these analyses is presented in Appendix R.

SECTION 3

BOILER OPERATING CONDITIONS

The Chevrolet Plant at Bay City, Michigan, includes manufacturing and administrative facilities as well as a powerhouse and a wastewater treatment facility. The wastewater treatment process was the source of the PCB-contaminated reclaim oil that was used for the verification burn. Reclaim oil was separated from the manufacturing facility process water and then filtered (20 micron) and centrifugated to ensure that water and solids content were each less than 0.1 percent. This reclaim waste oil was diluted, by volume, to a 1:9 ratio with No. 6 oil for firing to a high efficiency boiler in conformance with federal regulations (40 CFR 761.10).

The plant complex uses a powerhouse with three high efficiency boilers to produce steam, compressed air, and surface cooling water for the manufacturing plant. The three boilers in the powerhouse are Wickes Type "K" 65-4K-7 package boilers with a 60,000 lb/hr steam generation capacity at 8 gal/min No. 6 fuel oil feed rate. The No. 3 boiler that was used for the PCB waste oil burn was installed in 1965. During the verification burn, continuous monitors were used to measure carbon monoxide (CO), and oxygen (O_2), as prescribed by Federal regulations (40 CFR 761.10). Carbon dioxide (CO2) and total hydrocarbons (THC) were also continuously monitored at the stack above boiler No. 3. Provision was made for shutdown of waste fuel feed unless the following criteria were met:

- Boiler flame temperature - normal (∿2500°F)
- CO concentration - less than 50 parts per million (ppm)
- Excess O_2 - greater than 3 percent, and
- Opacity - less than 5 percent

An additional permit requirement was for steady-state operation with 4 gallons per minute fuel feed. Steady state operation was maintained during the burn by setting boiler No. 3 at base load and allowing boilers No. 1 and No. 2 to compensate for fluctuating steam demand. This is documented in both Boiler Operator Data (Appendix F) and Flue Gas Analysis (Appendix M).

Steady operation of the boiler was the responsibility of GM personnel. Table 6 presents the specific boiler parameters routinely monitored by GM during the burn. The flue gas parameters and composition were monitored by GCA. Any changes in flue gas readings were noted and relayed to GM personnel so that appropriate action could be taken.

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TABLE 6. COMBUSTION PARAMETERS MONITORED ROUTINELY BY GM

Parameter monitored	Instrument range	Normal parameter range
Fuel oil temperature	50-300°F	Ambient-200°F
Fuel oil flow rate	0-8 gpm	1-8 gpm
Atomizing steam pressure	0-160 psig	15-110 psig
Steam flow rate	0-70 Mlb/hr[a]	10-70 Mlb/hr[a]
Smoke density (in-stack)	1-100%	5-20%
Windbox pressure	0-10" w.c.[b]	0.5-7.5" w.c.[b]
Firebox pressure	0-10" w.c.[b]	0-5.5" w.c.[b]
For air preheater		
Air temperature in	0-600°F	Ambient
Air temperature out	0-600°F	250-350°F
Gas temperature in	0-600°F	350-580°F
Gas temperature out	0-600°F	200-300°F
Air pressure in	0-15" w.c.	0.5-10.5" w.c.
Air pressure out	0-15" w.c.	0.5-8.0" w.c.

[a] Mlb/hr - thousand pounds per hour.

[b] w.c. - water column.

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Data obtained by GCA from their continuous monitoring for O_2, CO_2, CO, and THC are presented in Table 7. The remaining parameters, those measured by GM, are summarized in Table 8. These latter boiler parameters were recorded at 15-minute intervals during each PCB test run. A full log of these recorded values is presented in Appendix F. Boiler operation was very steady with the exception of Day 4. Problems encountered on Day 4, though only apparent in the off-scale oxygen reading in Table 7, can be seen in Appendix F and Table 8. While none of the acceptable boiler parameter limits were exceeded during Day 4, the range of recorded values for several parameters were from two to five times greater than the corresponding range for the other test days, as shown in Table 8. Items such as air heater temperature and pressure and windbox and furnace pressure varied significantly more on Day 4 than on Days 1, 2 or 3. Of all the variations, the one most indicative of a change in boiler operating conditions is that of the back-wall furnace temperature. The average temperature for this parameter on Day 4 was 10 percent lower than the other 3 days and the range of recorded values was four times as great. This lower back-wall temperature was apparently related to a plugging of the fuel feed line. This plugging problem caused premature termination of the 4th Day's burn and is explained in Appendices O and P.

The stack gas concentrations of O_2, CO_2, CO, and THC for each burn period were determined by GCA using continuous emission monitors calibrated twice daily using certified (±1 percent) calibration gases from Scott Environmental Technology Accublend^{TM} cylinders.

The aforementioned gas sample was extracted continuously from a 2-inch port in the flue gas duct directly above the boiler and drawn through a Thermo-Electron Model 600 Flue Gas Conditioner to remove moisture (by condensation) and particulates (by filtration through glass fiber-filter media). The clean, dry, flue gas sample was then pumped to each continuous monitor for analysis as outlined in Figure 1.

In addition to the boiler operating measurements listed in Table 8, the following instruments and parameters were added during the verification burn:

- An infrared pyrometer for flame temperature.
- A custom thermocouple for furnace gas temperature.
- An ultrasonic flowmeter for relaim oil flow.

GM personnel were responsible for these measurements.

A complete discussion of all monitoring equipment used is included in Appendix A.

TABLE 7. FLUE GAS ANALYSES FOR O_2, CO, CO_2, THC

Date sampled	Oxygen (%)			Carbon dioxide (%)			Carbon monoxide (ppm)			Total hydrocarbons (ppm)		
	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
Day 1 - 5-05-80	5.6	6.7	6.3	11.2	13.4	12.3	12.3	16.7	14.2	1.3	3.1	2.2
Day 2 - 5-08-80	5.3	7.3	6.1	12.0	21.3	14.1	6.8	9.7	8.7	0.2	0.8	0.4
Day 3 - 5-09-80	3.9	8.0	5.6	8.3	12.6	11.3	8.0	11.0	9.6	0.7	2.4	1.4
Day 4 - 5-10-80	5.3	>10.23[a]	6.5	6.7	13.12	11.2	7.2	12.4	8.0	0.5	2.3	0.8
Lowest minimum value	3.9			6.7			6.8			0.2		
Highest maximum value		>10.23			21.3			16.7			3.1	
Average 4-day test period value			6.1			12.4			10.2			1.2
Standard deviation for 4-day test period average value	6.1 ± 0.46			12.4 ± 1.36			10.2 ± 2.48			1.2 ± 0.8		

[a] Reading off scale

Note: All readings are 15-minute averages unless stated otherwise.

TABLE 8. SUMMARY OF BOILER OPERATING PARAMETERS

Parameter Monitored	Statistical Classification	Background May 5, 1980	First PCB May 8, 1980	Second PCB May 9, 1980	Third PCB May 10, 1980
Fuel Oil Pressure (psig)	Acceptable	15/120	15/120	15/120	15/120
	Average	39	37	39	31
	Range	2	3	7	10
	Std. Dev.	0.87	1.1	1.8	2.9
Fuel Oil Flow Rate (gpm)	Acceptable	3.9/4.1	3.9/4.1	3.9/4.1	3.9/4.1
	Average	4.0	4.0	4.0	4.1
	Range	0	0.1	0.2	0.3
	Std. Dev.	0	0.04	0.055	0.96
Steam Flow Rate (Mlb/hr)	Acceptable	10/70	10/70	10/70	10/70
	Average	39	40	39	32
	Range	3	5.5	4.5	10
	Std. Dev.	1.0	1.6	1.3	3.3
Air Heater Temperature Air In (°F)	Acceptable	ambient	ambient	ambient	ambient
	Average	78	66	65	61
	Range	9	5	4	8
	Std. Dev.	3.2	1.7	0.79	2.7
Air Heater Temperature Air Out (°F)	Acceptable	250/350	250/350	250/350	250/350
	Average	355	354	362	329
	Range	8	9	10	44
	Std. Dev.	2.38	3.13	2.67	13.0
Air Heater Temperature Gas In (°F)	Acceptable	350/580	350/580	350/580	350/580
	Average	478	506	522	453
	Range	12	20	20	108
	Std. Dev.	3.99	4.41	5.36	30.0
Air Heater Temperature Gas Out (°F)	Acceptable	200/300	200/300	200/300	200/300
	Average	N.O.	N.O.	N.O.	N.O.
	Range	N.O.	N.O.	N.O.	N.O.
	Std. Dev.	N.O.	N.O.	N.O.	N.O.
Windbox Pressure (in. w.c.)	Acceptable	0.5/7.5	0.5/7.5	0.5/7.5	0.5/7.5
	Average	4.3	5.7	6.1	4.1
	Range	0.5	1.0	0.5	3.0
	Std. Dev.	0.21	0.28	0.20	0.97
Furnace Pressure (in. w.c.)	Acceptable	0.5/5.5	0.5/5.5	0.5/5.5	0.5/5.5
	Average	3.2	4.3	4.7	3.0
	Range	0.5	1.0	0.5	3.0
	Std. Dev.	0.20	0.28	0.24	0.94
Flue Gas Opacity (%)	Acceptable	5 or less	5 or less	5 or less	5 or less
	Average	2	0	0.4	2
	Range	1.5	0	1.0	0
	Std. Dev.	0.4	0	0.5	0

(continued)

TABLE 8 (continued)

Parameter Monitored	Statistical Classification	Background May 5, 1980	First PCB May 8, 1980	Second PCB May 9, 1980	Third PCB May 10, 1980
Fuel Oil Temperature (°F)	Acceptable	160/220	160/220	160/220	160/220
	Average	192	202	194	200
	Range	6	8	15	12
	Std. Dev.	1.62	2.45	3.02	3.92
Atomizing Steam Press. (psig)	Acceptable	15/110	15/110	15/110	15/110
	Average	49	46	50	39
	Range	5	5	7	14
	Std. Dev.	1.2	1.5	1.3	3.3
Air Heater Pressure In (in. w.c.)	Acceptable	0.5/10.5	0.5/10.5	0.5/10.5	0.5/10.5
	Average	6.2	8.2	8.9	5.9
	Range	0.5	1.0	0.5	4.5
	Std. Dev.	0.18	0.42	0.21	1.3
Air Heater Pressure Out (in. w.c.)	Acceptable	0.5/8.0	0.5/8.0	0.5/8.0	0.5/8.0
	Average	4.8	6.1	6.6	4.3
	Range	0.5	1.0	1.0	3.5
	Std. Dev.	0.18	0.28	0.25	1.0
Steam Drum Water Level (in.)	Acceptable	±5" of ctr.	±5" of ctr.	±5" of ctr.	±5" of ctr.
	Average	1.0	1.0	1.0	1.0
	Range	0.75	0.25	0	0
	Std. Dev.	0.13	0.051	0	0
Flame Temperature (°F)	Average	2630	2600	2580	2630
	Range	50	75	50	100
	Std. Dev.	15.4	24.4	19.4	29.1
Back Wall Temperature (°F)	Average	1690	1660	1660	1500
	Range	35	45	120	420
	Std. Dev.	11.5	11.5	22.2	83.8
Oil Flow Ultrasonic (gpm)	Acceptable	(ref.)	(ref.)	(ref.)	(ref.)
	Average	N.O.	3.90	2.28	2.25
	Range	N.O.	2.30	3.22	5.10
	Std. Dev.	N.O.	0.852	0.878	1.50
Wind Speed (mph)	Average	9	12	13	19
	Range	10	7	15	16
	Std. Dev.	2.8	2.0	3.3	3.9
Wind Direction (Comp. Pt.)	Average	WNW	NW	W	SSW
	Range	90°	70°	90°	45°
	Std. Dev.	40°	20°	20°	20°

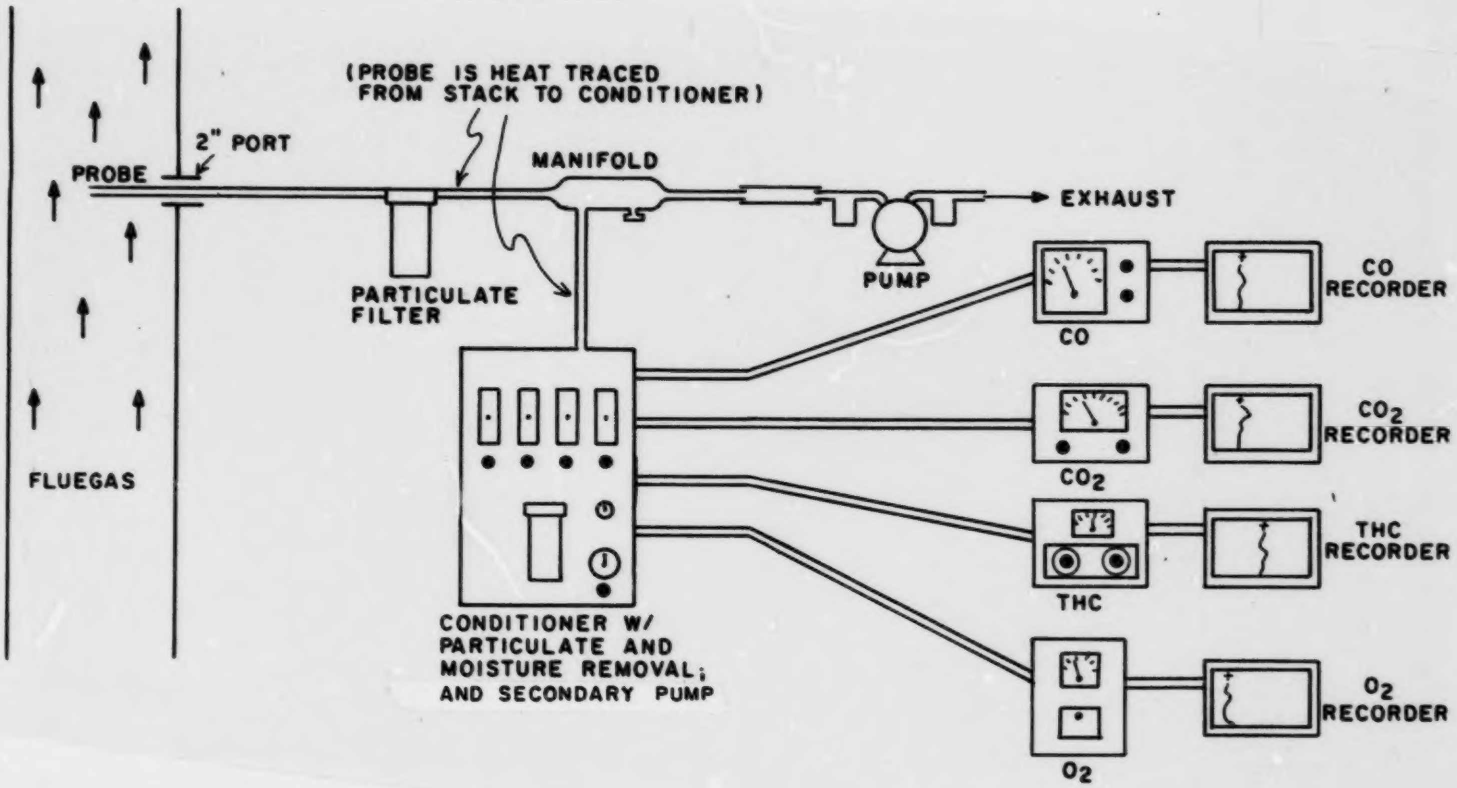
(PROBE IS HEAT TRACED FROM STACK TO CONDITIONER)
2" PORT
PROBE
MANIFOLD
EXHAUST
PARTICULATE FILTER
PUMP
FLUEGAS
CONDITIONER W/ PARTICULATE AND MOISTURE REMOVAL; AND SECONDARY PUMP
CO
CO RECORDER
CO2
CO2 RECORDER
THC
THC RECORDER
O2
O2 RECORDER

Figure 1. Flue gas continuous monitoring schematic.

The boiler combustion efficiency, as presented in Table 9, is computed based on average CO_2 and CO measurements, Table 7. The calculation of combustion efficiency is based on the following equation taken from Annex I of the PCB regulations (40 CFR 761). Table 9 indicates that the combustion efficiency for each test run was nearly identical, and that the combustion efficiency on Day 4, as measured by CO and CO_2 concentrations, was unaffected by the variations in certain boiler parameters.

$$\% \text{ C.E.} = \frac{\text{Conc } CO_2}{\text{Conc } CO_2 + \text{Conc } CO} \times 100$$

TABLE 9. BOILER COMBUSTION EFFICIENCY BASED ON CO_2 AND CO

	CO_2 (ppm)[a]	CO (ppm)[a]	% Combustion efficiency
Day 1 (5-05-80)	12.3×10^4	14.2	99.990
Day 2 (5-08-80)	14.1×10^4	8.7	99.994
Day 3 (5-09-80)	11.3×10^4	9.6	99.992
Day 4 (5-10-80)	11.2×10^4	8.0	99.993

[a] Based on an average of 15-minute average values.

SECTION 4

SAMPLING PROCEDURES

STACK EMISSIONS - PCB TRAIN

The PCB sampling of combustion flue gas included three complete days of boiler operations at normal load, burning No. 6 fuel oil and approximately 500 ppm PCB contaminated waste oil at a 9 to 1 ratio.

Waste oil was fed to the boiler only after combustion of No. 6 oil was steady and a normal burn temperature was established. It was calculated that a minimum sampling period of 6 hours would be required to yield approximately 10 μg of PCB for analysis. This was based on a destruction efficiency of 99.9 percent at the sampling conditions described below.

The sampling train used for PCBs was a modified Research Appliance Corporation (RAC) train as described in "Measurement of PCB emissions from Combustion Sources," (EPA-600/7-79-047).[3] A schematic of the train is shown in Figure 2.

The sampling and velocity traverse was along two diameters of the stack. A total of 44 points were thus sampled to provide a representative sample of the flue gas composition. Total sampling time was 308 minutes; 7 minutes per point on test days 1 through 3. The expected flow rate was approximately 0.6 ft^3/min. Sampling on test day 4 was only 210 minutes because an operator error caused shutdown of the fuel feed during the test, which resulted in a blockage of the feed line. This problem is more fully discussed in Appendix Q.

Sampling was isokinetic (±10 percent) with readings of flue gas parameters recorded at every sampling point during the traverse. In the event that isokinetic sampling could not be maintained, provisions were made for the train to be shut down and the problem remedied. No such problem was experienced during any of the test runs. In the event that either steady operation was not maintained, or monitored gas parameters (CO, CO_2, O_2) were out of the specified limits (40 CFR 761.10), the testing would have been stopped until conditions were stabilized. All monitored gas parameters remained within specified limits for each test run, as demonstrated in Table 7 and Appendix F.

The PCB sampling train uses a series of four impingers and a solid adsorbent tube as shown in Figure 2. The first two impingers contain deionized, distilled water. The third impinger is dry, while the fourth impinger contains silica gel. The solid adsorbent tube is a glass column

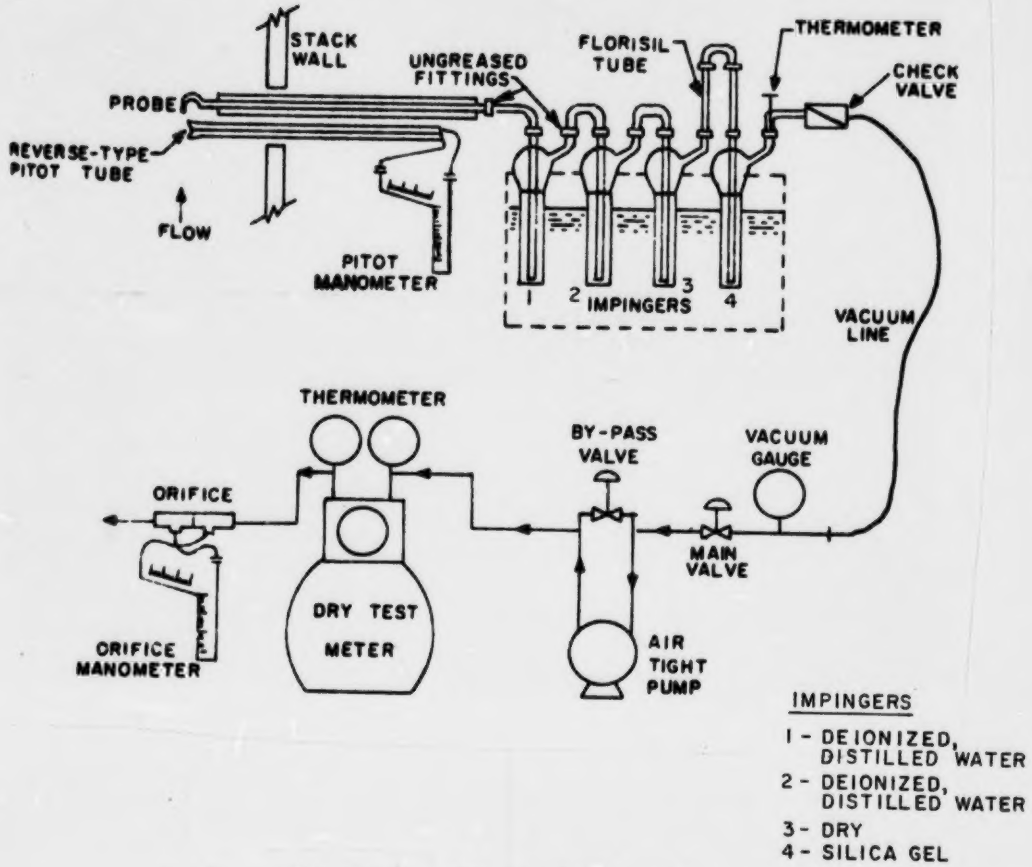
STACK WALL
UNGREASED FITTINGS
FLORISIL TUBE
THERMOMETER
CHECK VALVE
PROBE
REVERSE-TYPE PITOT TUBE
FLOW
PITOT MANOMETER
1
2
3
4
IMPINGERS
VACUUM LINE
THERMOMETER
BY-PASS VALVE
VACUUM GAUGE
ORIFICE
MAIN VALVE
DRY TEST METER
AIR TIGHT PUMP
ORIFICE MANOMETER
IMPINGERS
1 - DEIONIZED, DISTILLED WATER
2 - DEIONIZED, DISTILLED WATER
3 - DRY
4 - SILICA GEL

Figure 2. PCB sampling train.

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prepacked in the laboratory with 7.5 grams of pre-extracted 30/60 mesh Florisil activated at 130°C for 16 hours. The Florisil is secured in the tube with pre-extracted glass wool.

The PCB sampling method[3] requires that a field-biased blank train be set up and recovered with the sampling trains. One blank train was recovered with the sampling trains for each day of sampling.

In an attempt to provide a qualitative estimation of recovery efficiency, sampling trains were spiked in the field with deuterated tetrachlorobiphenyl. This was accomplished by adding a known amount of the deuterated isomer (dissolved in acetone) into the first impinger before the final leak check. Recovery and analyses of these spiked samples were inconclusive. Problems encountered with these samples are discussed in Section 7, Quality Assurance/Quality Control.

The sampling equipment was prepared for PCB testing at the GCA laboratory in Bedford, Mass.[4] The sequence used was the following: acid soak, alcoholic KOH soak, distilled deionized water rinse, acetone rinse, hexane rinse (in field). Glass sample bottles with Teflon-lined caps were also prepared in a similar manner.

STACK EMISSIONS - METHOD 5 TRAIN

The sampling train used to collect other organic compounds from the stack gas was a standard EPA Method 5 particulate train, modified to include an adsorbent column, as shown in Figure 3. This train was operated simultaneously with the PCB sampling train to provide real-time comparison samples for HCl, dibenzofuran, chlorinated dibenzofurans and chlorinated dioxins analyses. The sampling included a total of 44 points along the two stack diameters. Sampling was a 7 min per point for a total duration of 308 minutes. Samples of flue gas particulate were collected on a 4-inch glass fiber filter. In addition to total particulate, a temperature controlled adsorbent column was included in the sampling train to collect organic emissions from the flue gas. This column, shown in Figure 3, contains approximately 25 grams of XAD-2 resin. The temperature of the condenser is maintained at 70°F and the condensate is collected in the first impinger of the sampling train.

This sampling train was also used to determine HCl emissions from the flue gas. The second impinger of the Modified Method 5 train contained 200 ml of 8 percent Na_2CO_3/H_2O as a trapping solution for HCl emissions.

In addition to the second impinger solution, an aliquot (20 percent) of the first impinger water (condensate for XAD-2 resin trap) was taken and preserved by addition of Na_2CO_3. The remaining condensate (80 percent) was preserved in the field by the addition of distilled in glass (D.I.G.) methylene chloride.

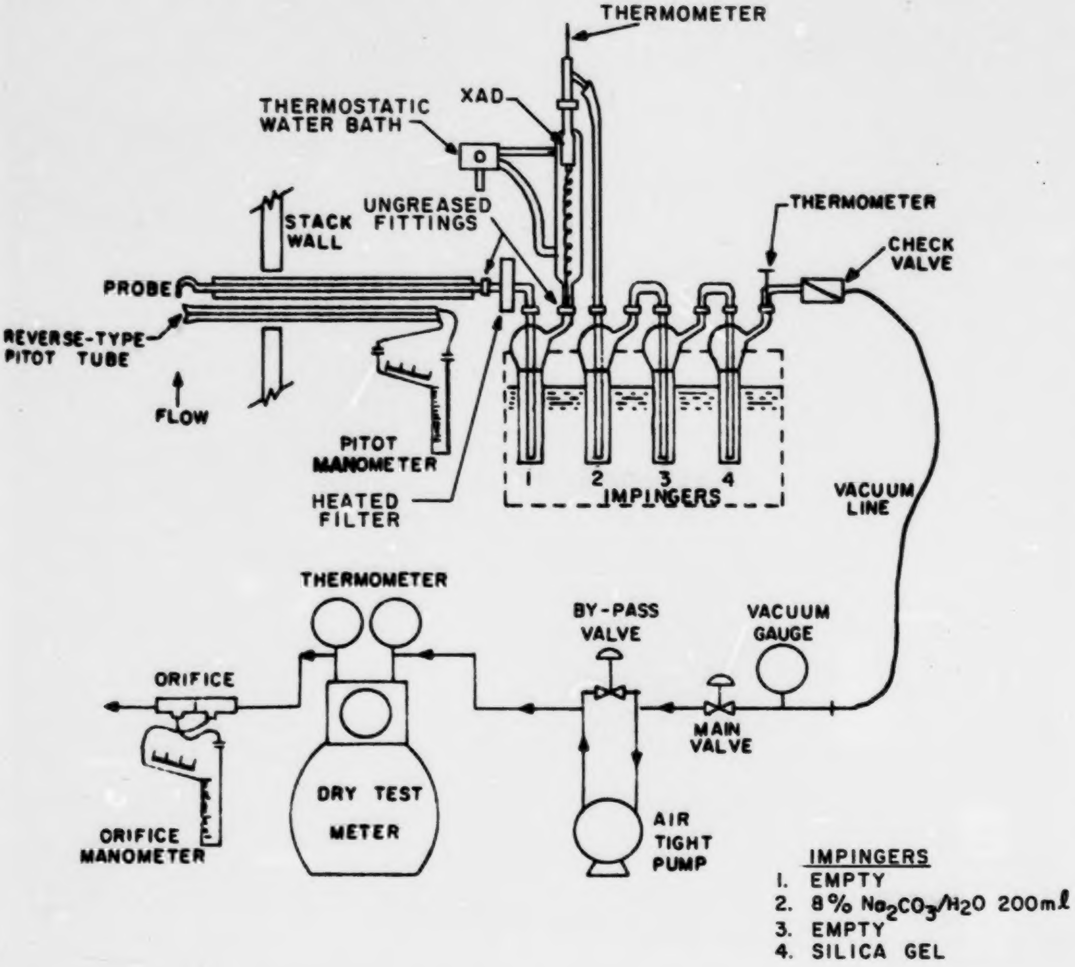

THERMOMETER
XAD
THERMOSTATIC WATER BATH
UNGREASED FITTINGS
STACK WALL
THERMOMETER
CHECK VALVE
PROBE
REVERSE-TYPE PITOT TUBE
FLOW
PITOT MANOMETER
HEATED FILTER
1
2
3
4
IMPINGERS
VACUUM LINE
THERMOMETER
BY-PASS VALVE
VACUUM GAUGE
ORIFICE
MAIN VALVE
DRY TEST METER
AIR TIGHT PUMP
ORIFICE MANOMETER
IMPINGERS
1. EMPTY
2. 8% Na_2CO_3/H_2O 200mℓ
3. EMPTY
4. SILICA GEL

Figure 3. Organic (Modified Method 5) sampling train.

SD

4-4

The sampling equipment was prepared in the same manner as the PCB train with the addition of a terminal rinse with dichloromethane (in field). Sample bottles used for organic samples were cleaned by the EPA Level 1 procedure, which substitutes a dichloromethane rinse for the final hexane rinse.[5] Nalgene sample bottles were used for HCl samples and were rinsed with 1:1 nitric acid followed by deionized distilled water rinses.

To provide background data on emissions from the boiler, a preliminary test was conducted with No. 6 fuel oil only, one day before the initiation of the 3-day PCB test burn. This test was for the same duration and at the same conditions as those to be used for the PCB sampling. The test included both a PCB train and a standard Method 5 particulate train. This test provided background information on the test conditions and also provided emissions data for the boiler as operated at normal load and firing No. 6 fuel oil.

Duplicate PCB trains were simultaneously operated on the second day of waste oil burning. The replicate measurements would serve as indication of the precision of stack collection of PCBs. The Modified Method 5 particulate train from that day was therefore replaced by the second PCB train. A recent study determined that chlorinated dibenzofurans were not a significant PCB combustion product of high temperature incineration.[6] In light of these findings, it was believed that the elimination of the Modified Method 5 train from one day's sampling would not eliminate any information that would be critical to the destruction efficiency calculations.

A complete listing of samples which were taken in the flue gas stream is found in Table 10. Field sample recovery adhered to those methods defined in the GCA test plan,[4] including Quality Assurance/Quality Control (QA/QC) procedures, as described in that report.

The PCB train measured the PCB output in the flue gas. In order to determine the PCB destruction efficiency during the test, it is necessary to measure the PCB input from the fuel being combusted.

IN-PLANT PCB MONITORING

Mine Safety Appliances Model-G personnel air sampling pumps were used to collect 16 breathing zone and 22 general area samples during the PCB verification burn. The sampling flow rate was controlled at either 200 cubic centimeters per minute (cc/minute) or at 500 cc/minute. The sample volumes ranged from approximately 25 to 170 liters of air, varying in proportion to the sample time as well as the flow rate. A complete listing of the breathing zone and powerhouse monitoring results is provided in Appendix J. A discussion of these results is provided on page 44 of Section 5.

PCB BLOOD CHEMISTRY SAMPLING

Blood samples were drawn from the 12 boiler operators and 39 other employees who had no work experience with PCB. The samples were split and sent to the State of Michigan Department of Health Laboratory in Lansing, Michigan and the Raltech Laboratory in Madison, Wisconsin for analysis. The results are given in Appendix L and discussed on page 44 of Section 5.

TABLE 10. SAMPLES COLLECTED AT GENERAL MOTORS BOILER HOUSE

Sample	Source	Container	Species analyzed	Number of samples
Flue gas particulate	Method 5 filter	Aluminum foil	Polychlorinated dibenzofurans	3
Flue gas particulate	Method 5 rinse	Amber glass	Total particulate	3
XAD-2 resin	Method 5 trap	Amber glass	Total organic residue	3
Condensate, preserved	Aliquot, Method 5 condenser	Nalgene	HCl	3
Condensate extracted	Method 5 condenser	Amber glass	Total organic	3
Na_2CO_3 solution	Method 5 second impinger	Nalgene	HCl	3
Florisil resin	PCB train	Amber glass	PCBs	5
Condensed water impinged particulates	PCB train impingers	Amber glass	PCBs	5
Train wash	D.I.G. hexane D.I.G. acetone	Amber glass	PCBs	5
Florisil blank	Blank PCB train	Amber glass	PCB background	4
Train wash blank	Blank PCB train	Amber glass	PCB background	4
Filter blank	Filter lot sample	Petri dish	Background polychlorinated dibenzofurans	1
XAD-2 blank	XAD-2 lot sample	Amber glass	Background organics	2
CH_2Cl_2 blank	CH_2Cl_2 sample	Amber glass	Background organics	2
Na_2CO_3 blank	Solution blank	Nalgene	Background HCl	2
Fuel feed	Trickle value (integrated)	Amber glass	Polychlorinated dibenzofurans, PCB	4

BOILER PCB RESIDUAL SAMPLING

Samples of residue were scraped from eight locations in the boiler and exhaust system before the verification burn. Samples from 10 locations were scraped after the burn. All the samples were sent to the General Motors Industrial Hygiene Laboratory for analysis. The results are given in Appendix K and discussed on page 45 of Section 5.

FUEL SAMPLING FOR WASTE, SPIKED AND MIXED OILS

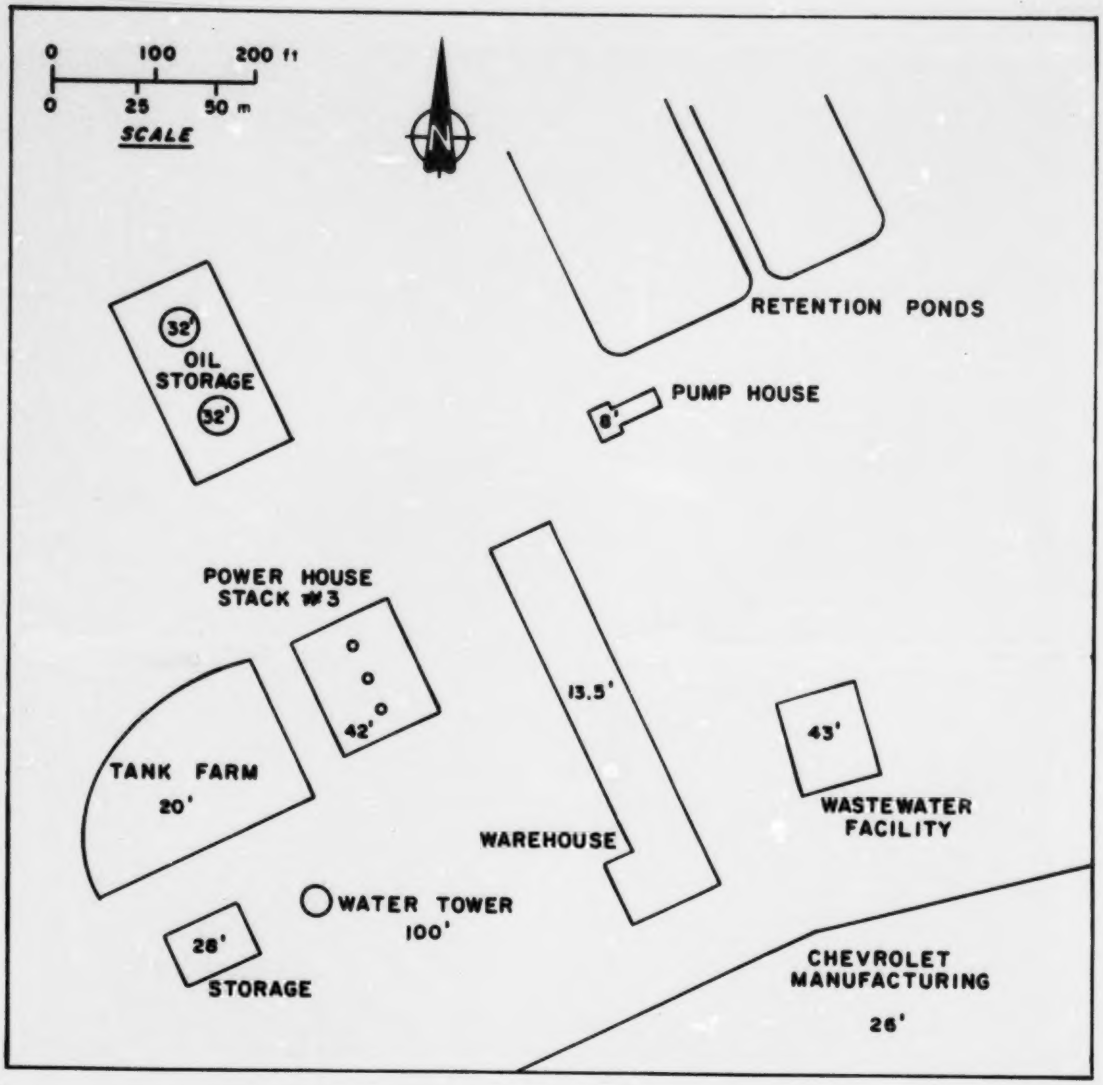
A sample of the waste oil to be fired during the verification test was taken from the waste oil storage tank after thorough mixing. The sample was split and sent to the four laboratories listed in Appendix G. The waste oil was analyzed for PCBs, dibenzofurans, dioxins, as well as nitrogen, sulfur, chlorine, carbon, hydrogen, ash, water, sediment, calorific value, carbon residue and flash point. GM retained a fuel sample for their own analytical determinations. The spiked oil sample was prepared in the laboratory at Chevrolet-Bay City from this retained waste oil sample and the spiked fluid. The spiked oil sample was split and sent to the GCA and Chevrolet laboratories for analysis. A requisite QA/QC audit which included a separate analysis, was performed by the Health Effects Research Laboratory of O.R.D.[2] The mixed oil samples were extracted from the fuel oil line to the boiler during each test run. These samples were split and sent to the GCA and Chevrolet laboratories for analysis. The results of the various oil analysis are given in Appendix G and discussed in Section 5.

AMBIENT PCB MONITORING

Network Design

The ambient monitoring network was designed to measure PCB concentrations in the ambient air on plant property and in the immediate populated area expected to be downwind of stack emissions from the test burns. Meteorological conditions on each test day were used to position the monitors in areas on the plant property where maximum impact from the stack effluent was predicted. In this way, it was hoped to have a basis for determining background levels, population exposure, and increases in concentrations of PCBs due to the test burn. Figure 4 shows the location of the powerhouse with respect to nearby plant facilities. Figure 5 shows the locations of neighboring residential and commercial areas.

Monitors were positioned each morning based on weather forecasts, onsite wind conditions (measured at the stack by a continuously monitoring wind system) and predicted plume dispersions. Table 11 was used with forecasted meteorological conditions, to predict atmospheric stability category for the burn period.


0
100
200 ft
0
25
50 m
SCALE
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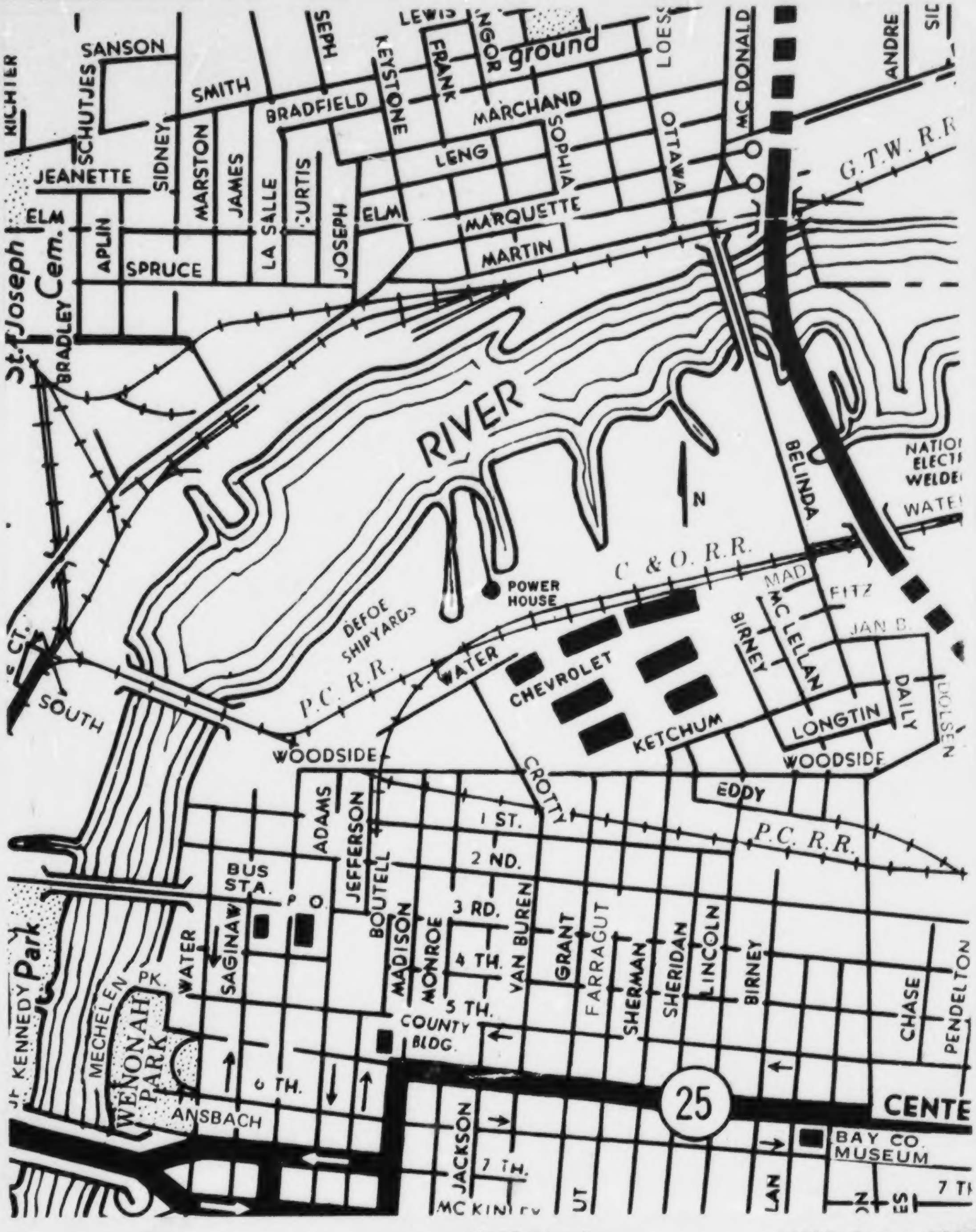
RETENTION PONDS
32'
OIL STORAGE
32'
PUMP HOUSE
8'
POWER HOUSE STACK #3
42'
13.5'
43'
TANK FARM
20'
WASTEWATER FACILITY
WAREHOUSE
WATER TOWER
100'
28'
STORAGE
CHEVROLET MANUFACTURING
26'

Figure 4. Plot plan of plant facilities. Structure heights are indicated in feet.


LEWIS
SEPH
KEYSTONE
FRANK
NGOR
ground
LOESS
MC DONALD
ANDRE
SID
KICHIER
SANSON
SMITH
BRADFIELD
MARCHAND
SCHUTJES
SIDNEY
MARSTON
JAMES
LA SALLE
CURTIS
LENG
SOPHIA
OTTAWA
G.T.W. R.R.
JEANETTE
ELM
APLIN
SPRUCE
JOSEPH
ELM
MARQUETTE
MARTIN
St. Joseph Cem.
BRADLEY
RIVER
N
BELINDA
NATIONAL ELECTRIC WELDER
WATER
C. & O. R.R.
POWER HOUSE
DEFOE SHIPYARDS
MAD
FITZ
MC LELLAN
BIRNEY
JAN B.
CHEVROLET
P.C. R.R.
WATER
ST. CT.
SOUTH
WOODSIDE
KETCHUM
LONGTIN
DAILY
OLSEN
WOODSIDE
EDDY
CROTTY
ADAMS
JEFFERSON
BOUTELL
1 ST.
P.C. R.R.
2 ND.
BUS STA.
P.O.
3 RD.
VAN BUREN
GRANT
FARRAGUT
SHERMAN
SHERIDAN
LINCOLN
BIRNEY
PENDELTON
WATER
SAGINAW
MADISON
MONROE
4 TH.
5 TH.
CHASE
KENNEDY Park
MECHELEN PK.
WENONAH PARK
COUNTY BLDG.
6 TH.
25
CENTER
ANSBACH
JACKSON
BAY CO. MUSEUM
7 TH.
7 TH.
MC KINLEY

SCALE 1cm = 100m

Figure 5. Map of Bay City near the GM plant.

4-10

After establishing an expected mean downwind direction, plume width information, such as that provided in Figure 6, was used in conjunction with Figure 7 to locate the two monitors for maximum ambient plume impact. The curves shown in Figures 6 and 7 have been calculated for 3-hour release times. The goal was to select a compromise distance suitable for all expected stabilities during the 12-hour monitoring time. Consideration was also given to any anticipated hotspots from plume downwash, if effluent dispersion was predicted over a nearby building. This selection was conducted with the State of Michigan representative at the test burn.

TABLE 11. KEY TO STABILITY CATEGORIES[7]

	Day			Night	
Surface wind speed (at 10 m) m sec^{-1}	Incoming solar radiation			Thinly overcast or ≥ 4/8 low cloud	≤ 3/8 cloud
	Strong	Moderate	Slight		
2	A	A-B	B		
2-3	A-B	B	C	E	F
3-5	B	B-C	C	D	E
5-6	C	C-D	D	D	D
6	C	D	D	D	D

The monitor locations that were used during the test program are shown in Figures 8, 9 and 10.

Test Scheduling

Ambient sampling occurred on the same days as the stack sampling; i.e., 1 day specified as a background burn (No. 6 fuel oil only) followed by 3 days at burning a combination of No. 6 oil and PCB-contaminated reclaim oil. The monitors were operated in a synchronized manner with the stack samples.

Four runs, each three hours in duration, comprised the 12-hour ambient monitoring sample period. These four runs were one preburn, one post-burn, and two runs during the waste oil burning which were combined for analysis. Testing coordination was designed so that no reclaim oil would enter the boiler until the 3-hour preburn run was complete. The post-burn ambient sampling run was not started until after a time, derived from prevailing wind velocity, when any PCB contaminated effluent from the stack would have passed by the monitors.

Sampling Method

High volume sampling of ambient air was performed with samplers modified as described in "A Method for Sampling Analysis of Polychlorinated Biphenyls (PCBs) in Ambient Air" (EPA-600/4-78-048).[8] This modification involved an extension of the throat assembly at the sampler with a piece of cylindrical aluminum, threaded on one end. The other end was fitted with an aluminum flange, which supported the motor housing. Motor exhaust was directed away

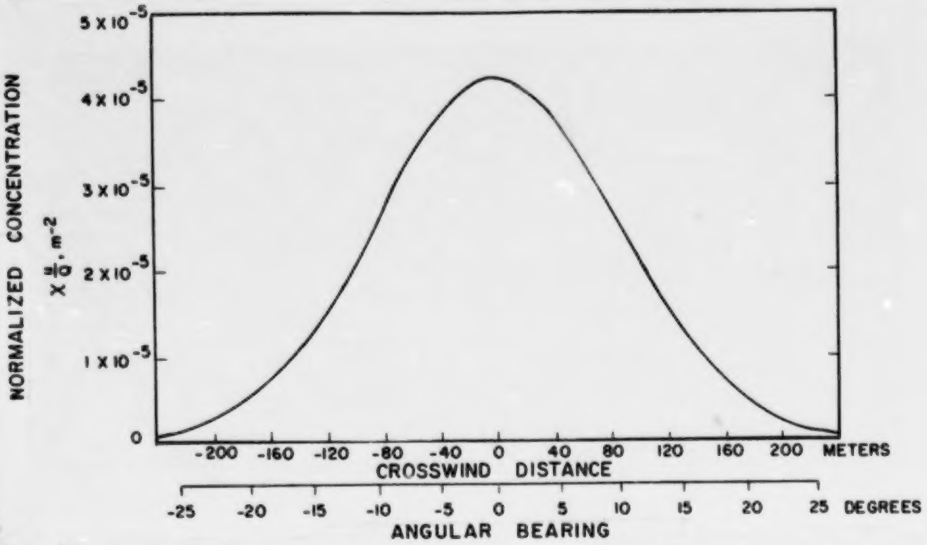


Figure 6. Normalized concentration as a function of crosswind distance and angular bearing for C stability. Distance from stack is 480 meters.

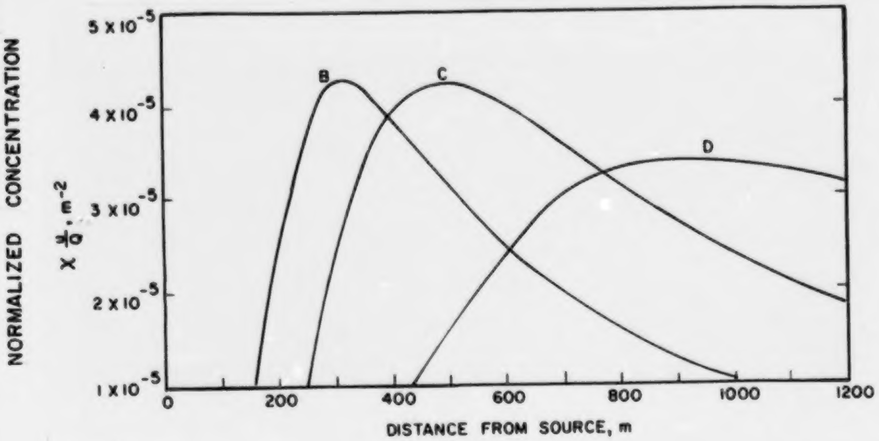


Figure 7. Normalized concentration as a function of distance from stack for three stability conditions.

χ = g/m^3 pollutant
N = m/sec wind speed
Q = g/sec pollutant emission rate

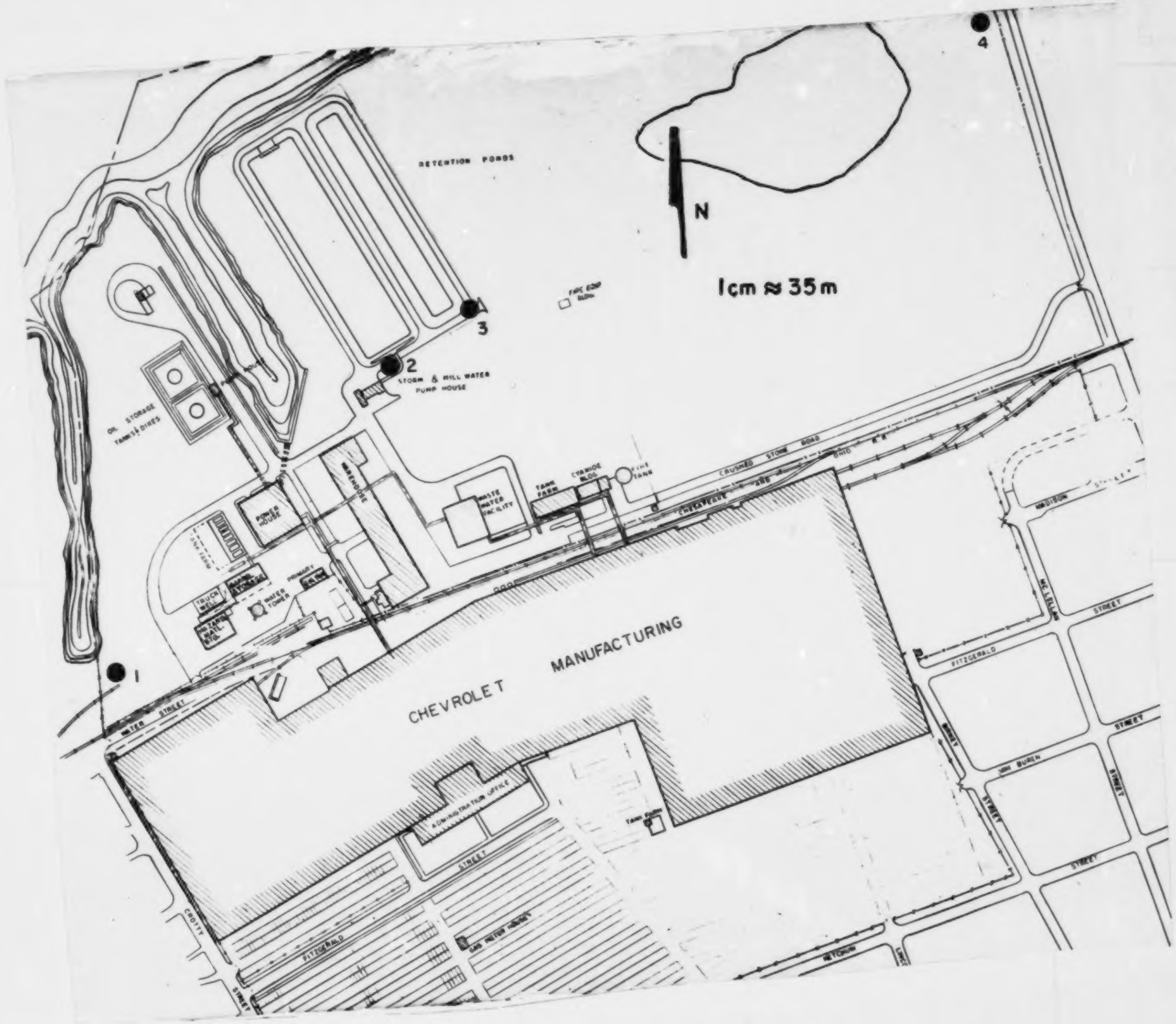

RETENTION PONDS
N
1cm ≈ 35m
4
3
2
STORM & MILL WATER PUMP HOUSE
OIL STORAGE TANKS & DIKES
POWER HOUSE
WAREHOUSE
WASTE WATER FACILITY
TANK FARM
CYANIDE BLDG
FIRE TANK
CRUSHED STONE ROAD
WATER TOWER
1
WATER STREET
CHEVROLET MANUFACTURING
ADMINISTRATION OFFICE
TANK FARM
STREET
CROTTY
FITZGERALD
STREET
MADISON STREET
MC LELLAN
STREET
FITZGERALD
BIRNEY
STREET
VAN BUREN
STREET
STREET
STREET
HITCHCOCK

Figure 8. Ambient monitor location - day 1.

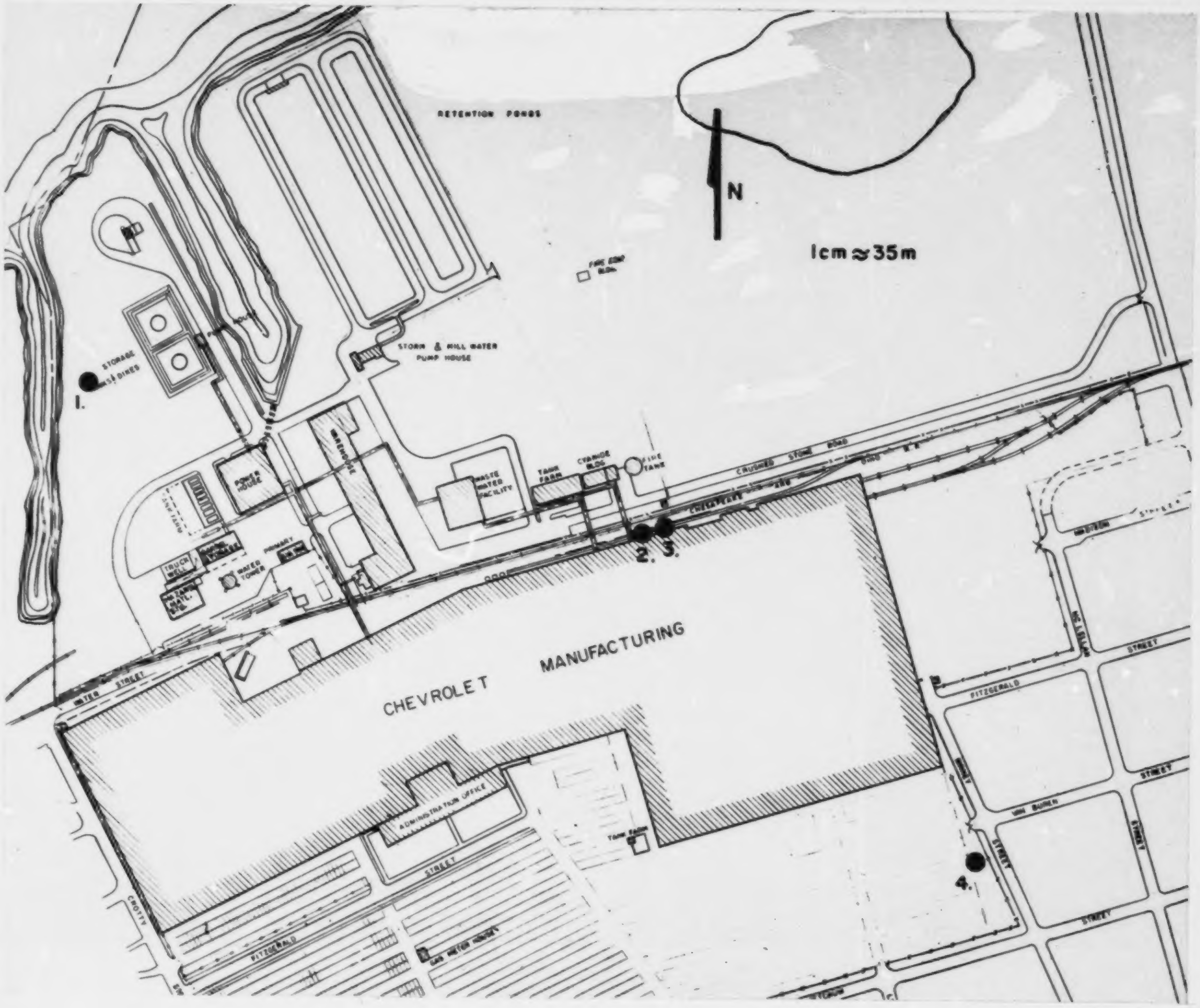

RETENTION PONDS
N
1cm ≈ 35m
FIRE EQUIP. BLDG.
STORM & MILL WATER
PUMP HOUSE
STORAGE
SLAG DIKES
1.
POWER HOUSE
TANK FARM
TRUCK WELL
WATER TOWER
PRIMARY
WASTE WATER FACILITY
TANK FARM
CYANIDE BLDG.
FIRE TANK
CRUSHED STONE ROAD
CHESAPEAKE
2.
3.
CHEVROLET
MANUFACTURING
WATER STREET
ADMINISTRATION OFFICE
GAS METER HOUSE
STREET
FITZGERALD
CROTTY
FITZGERALD
MC LELLAN
STREET
VAN BUREN
STREET
STREET
STREET
4.

Figure 9. Ambient monitor location - days 2 and 3.

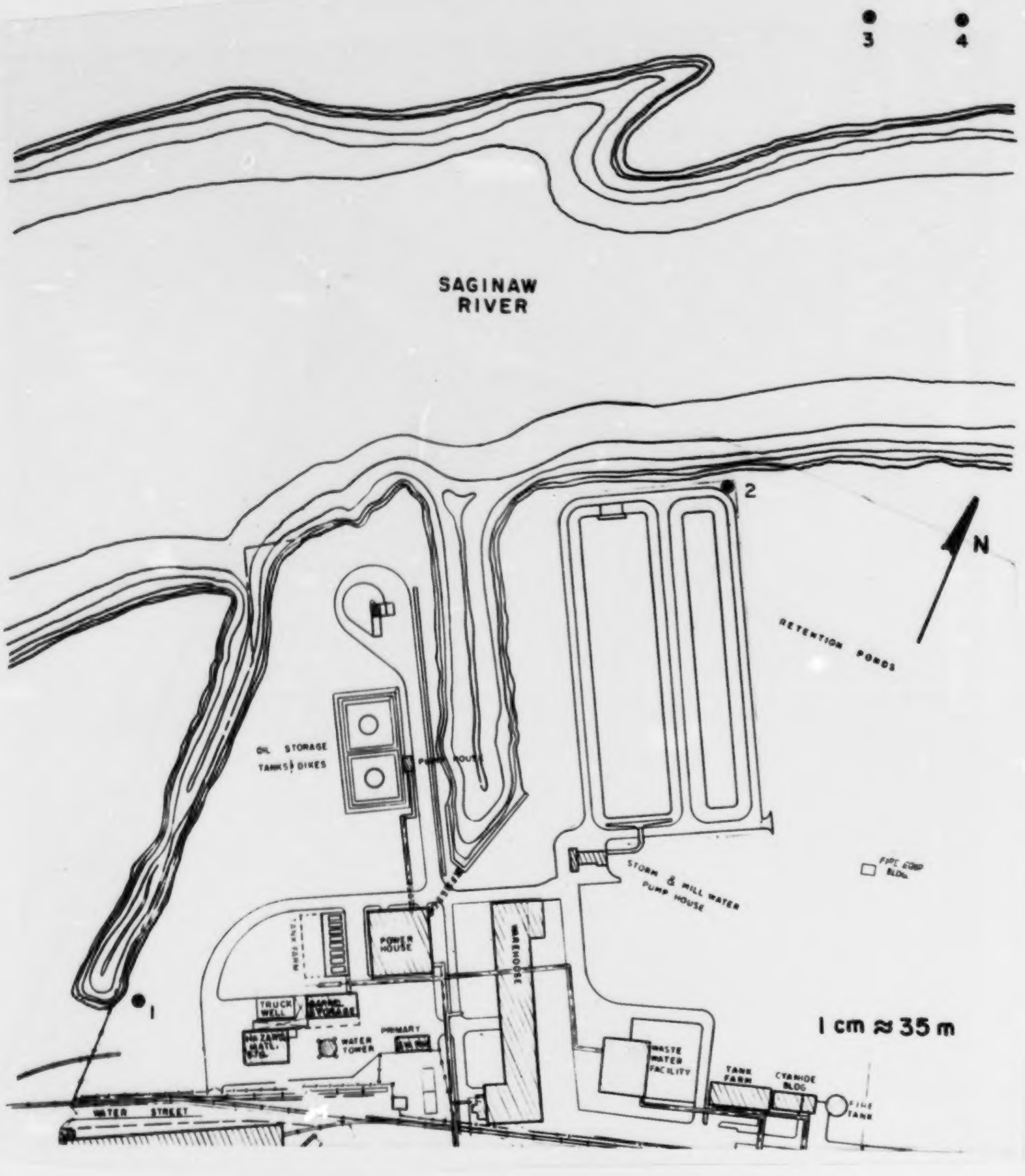

3
4
SAGINAW RIVER
2
N
RETENTION PONDS
OIL STORAGE TANKS & DIKES
PUMP HOUSE
STORM & MILL WATER PUMP HOUSE
PIPE SHOP BLDG.
TANK FARM
POWER HOUSE
WAREHOUSE
TRUCK WELL
BARREL STORAGE
HAZARD. MATL. STG.
WATER TOWER
PRIMARY
1
1 cm ≈ 35 m
WASTE WATER FACILITY
TANK FARM
CYANIDE BLDG
FIRE TANK
WATER STREET

Figure 10. Ambient monitoring locations - day 4.

from the sampler intake by flexible ductwork (Figure 11) positioned downwind. A sheet metal attachment was required and added to adapt the motor housing to the ductwork. Airborne PCB was collected on a series of two precleaned polyurethane foam plugs housed in the sampler throat. Flow rate through the sampler was between 10 and 30 ft^3/min. These flow rates were selected since experimental data has shown that this range maximized PCB capture while minimizing the possibility of breakthrough of PCB isomers through the polyurethane foam plugs.[8]

The sampling sites consisted of two hi-volume samplers which were designed to provide continuous sampling for the 12-hour period. Two timer systems were required for this. One timer automated the switching sequence between samplers at 3-hour intervals. The second timer provided precise measurement of sampling time at each location. These measurements coupled with flowmeter readings at the beginning and end of the sampling period were used to determine the actual sampled air volume.

Equipment Preparation

Extensive cleaning procedures were required to adequately prepare any surfaces that would come in contact with materials used for analytical samples. All metal work; e.g., foam plug extensions, filter holder and throat, flange to motor support, followed the following cleaning sequence: acid soak, water rinse, distilled deionized water rinse, acetone rinse, hexane rinse (in field).

All equipment that was used in contact with the foam plugs and filters were hexane washed prior to their use. This included tongs, throat extensions, Teflon gaskets and filter holder. Quality control procedures used with the ambient sampling equipment are further discussed in Section 7.

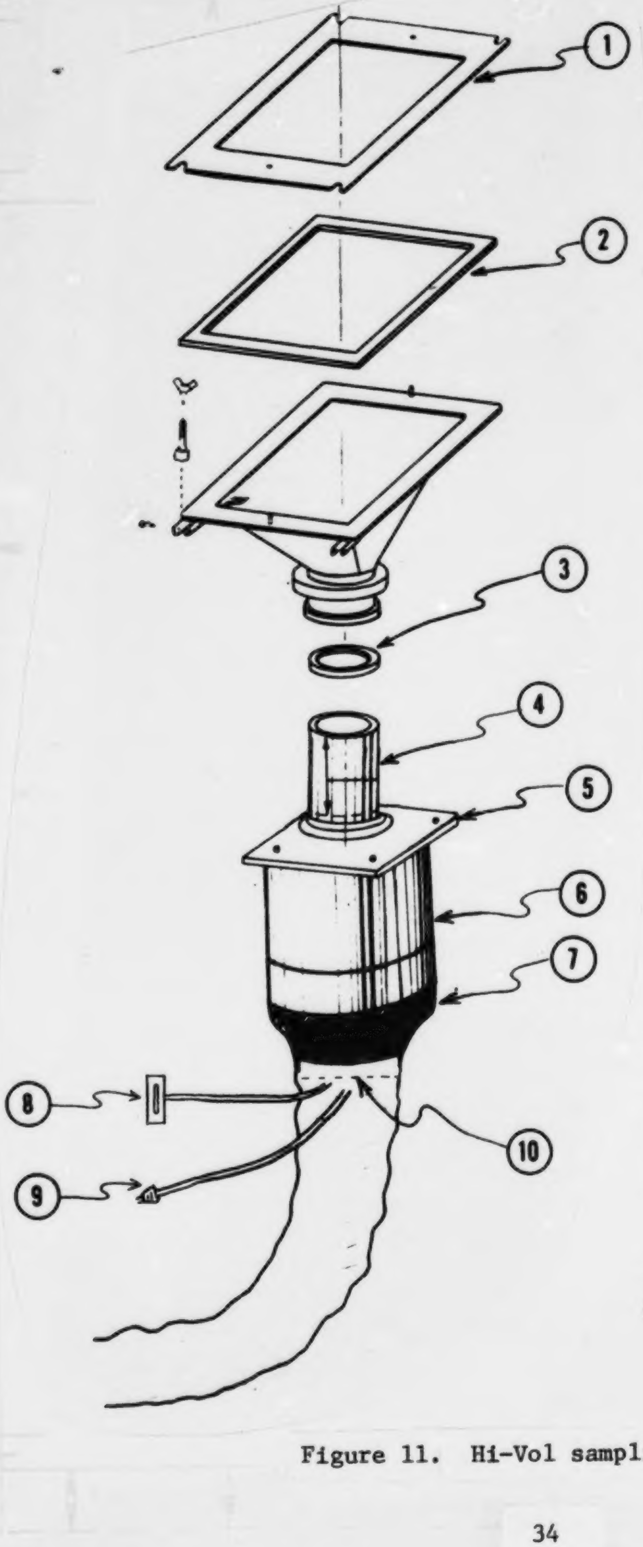
Filter Preparation

Filters used for the test were Celman type A-E, glass fiber filters, heated (200°C) and wrapped in rinsed, aluminum foil.

Foam-Plug Preparation

The polyurethane foam was prepared using the procedures described in "A Method for the Analysis of Polychlorinated Biphenyls (PCB) in Air" (EPA-600/4-78-048)[8] and "High Volume Collection of Atmospheric Polychlorinated Biphenyls,"[9] requiring overnight soxhlet extraction using 9:1 hexane:ethyl ether.

Plugs were prepared and labeled in lots of 15. Two foam plugs from each lot were chosen at random and re-extracted in hexane for quality control purposes.



(1) Filter holder support
(2) Teflon gasket
(3) Teflon gasket
(4) Aluminum throat extension and foam plugs
(5) Aluminum flange & motor support
(6) HiVol motor
(7) Sheet metal adaptor for exhaust duct
(8) Rotometer
(9) Power cord
(10) Exhaust duct

Figure 11. Hi-Vol sampling apparatus.

SECTION 5

ANALYTICAL PROCEDURES AND RESULTS

PCB ANALYSIS

Five sampling runs were conducted for PCB emissions. These consisted of four samples taken while the PCBs were present in the fuel and a background sample. All sampling runs were conducted in the same manner. As described in Section 3, all nonblank trains were spiked to assess PCB sampling efficiency. Each of these trains generated three types of samples: (1) a Florisil cartridge, (2) a series of water impingers, and (3) combined hexane and acetone rinses. An analysis flow scheme is outlined in the test plan.[4]

Contents of each of the Florisil adsorbent tubes was Soxhlet extracted with a given volume of hexane (200 ml) for at least 4 hours. Upon completion of extraction, the apparatus was allowed to cool and the contents combined with the appropriate impinger extract and train rinse.

The impinger waters were returned to the lab as one combined sample. The aqueous sample in each case was transferred to a liter separatory funnel. The sample container was rinsed with acetone and hexane which were in turn added to the separatory funnel. The sample was extracted with three 100 ml portions of hexane which were then combined with the Florisil adsorbent tube extract and the concentrate of the hexane and acetone rinses. This combined extract was dried via a sodium sulfate column and rotary evaporated (40°C) to less than 10 ml.

This extract was transferred to a 50 ml separatory funnel and partitioned against concentrated sulfuric acid. The layers were allowed to separate and the acid layer discarded. Further cleanup was not necessary at this point since all samples extracts were colorless.

The extract was aliquotted for each of three quantitative procedures plus a 1 ml reserve for prescreening by gas chromatography with electron capture detection (GC/ECD) and chromatography/mass spectrometry (GC/MS). Results indicated that further cleanup was unwarranted, and the remaining 9 ml was divided into three 3 ml aliquots. To each portion was added a d_{10}-anthracene internal standard for quantitation by GC/MS selected ion monitoring (SIM). The GC/MS quantitative data was collected on an HP-5985 GC/MS data system, using the parameters listed in Appendix A, Table A-1.

Instrument calibration was accomplished using standards obtained from RFR, Inc., Hope, Rhode Island, which were weighed and diluted into hexane. The GC/MS characteristics of calibration standards are listed in Appendix A, Table A-2.

The extract was analyzed by gas chromatography coupled with an electron capture detector (GC/ECD). A Hewlett-Packard 5840A with Model 7671A automatic liquid sampler was used for this analysis. The GC/ECD parameters for the analysis are listed in Appendix A, Table A-3.

Instrument calibration was accomplished using an Aroclor 1242 solution distributed by Applied Science Labs, Inc., State College, Pennsylvania. Calibration standards of chlorinated biphenyl isomers were supplied by RFR, Inc., Hope, Rhode Island.

After GC/ECD analysis, one of the 3 ml aliquots was divided into two portions, and then perchlorinated. The analytical procedure employed is summarized here.

Chloroform was successively added to the hexane extract and azeotrophic evaporation carried out in a microconcentrator apparatus to a sample volume of 1.0 ml. The sample was then transferred to a reaction vial and the volume reduced to 0.1 ml for perchlorination. A 0.2 ml portion of $SbCl_5$ was added and the capped reaction vial heated at 160 (± 3°C) for 3 hours.

At the conclusion of this reaction period, the vial was air-cooled and finally cooled in an ice bath to 0°C. The residual $SbCl_5$ was neutralized by the addition of 1 ml of 6 N HCl. Subsequent steps include 3 X 1 ml extractions of hexane, followed by a Na_2SO_4 drying procedure. The total hexane volume is eventually reduced to 1 ml prior to quantitation. A GC/ECD procedure was used to quantitate the decachlorobiphenyl (DCB) in the sample by comparison of the peak area with that of a known concentration of a DCB standard. Computed DCB values were then converted to approximate equivalent PCB values by utilizing the values summarized in **Table 12**. A Perkin-Elmer 3920 gas chromatograph with a Ni^{63} electron capture detector was used to quantitate DCB in the extract. Instrumental parameters are listed in Appendix A, Table A-4. Detection of DCB in sample extracts would indicate need for GC/MS confirmation and correction for any biphenyl contained in the unperchlorinated extract.

Results of GC/ECD and GC/MS analysis of stack samples presented in **Table 13** show that levels of Aroclor 1242 found in the samples were below detectable levels in both analyses; i.e., less than 0.001 mg and 0.002 mg, respectively.

METHOD 5 TRAIN ANALYSIS

Operated simultaneously with the PCB train, the Method 5 train provided a total of two runs during PCB burning plus a blank run with No. 6 fuel oil only. Each Method 5 train produced four types of samples: (1) particulates collected on a filter, (2) XAD adsorbent resin, (3) impinger condensates and (4) rinses. Their respective analytical schemes are shown in **Figures 12** and 13.

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TABLE 12. FACTORS TO MATHEMATICALLY CONVERT DECACHLOROBIPHENYL TO AN EQUIVALENT AMOUNT OF AROCLOR[a]

Aroclor	Average No. Cl[b]	MW[a]	X[c]
1221	1	188.5	0.38
1232	2	223	0.45
1242	3	257.5	0.52
1016	3	257.5	0.52
1248	4	292	0.59
1254	5	326.4	0.65
1260	6	361	0.72
1262	7	395.3	0.79
DCB	10	499	1.00

[a] Molecular weight of Aroclor based on the average whole number of chlorines calculated from percent chlorine substitution.

[b] Average whole number of chlorines calculated from percent chlorine substitution for a specific Aroclor.

[c] X = molecular weight Aroclor/molecular weight DCB (499). To convert ppm DCB to ppm for a specific Aroclor, multiply ppm x DCM by X for the Aroclor.

TABLE 13. RESULTS OF STACK SAMPLE ANALYSES FOR PCB

Run number	Test day	Extract volume (ml)	Weight (mg) detected of Aroclor 1242 (GC/ECD)	Weight (mg) detected of Aroclor 1242 (GC/ECD)[a]	Weight (mg) detected of chlorinated biphenyl isomer (GC/MS)
PCB-1	1	10.0	<0.001	<0.002	<0.01
PCB-2	2	10.0	<0.001	<0.002	<0.01
PCB-3	3	10.0	<0.001	<0.002	<0.01
PCB-4	3	10.0	<0.001	<0.002	<0.01
PCB-5	4	NA[b]	-	-	-

[a] Using perchlorination technique.

[b] NA = Sample extract lost during analysis sequence.

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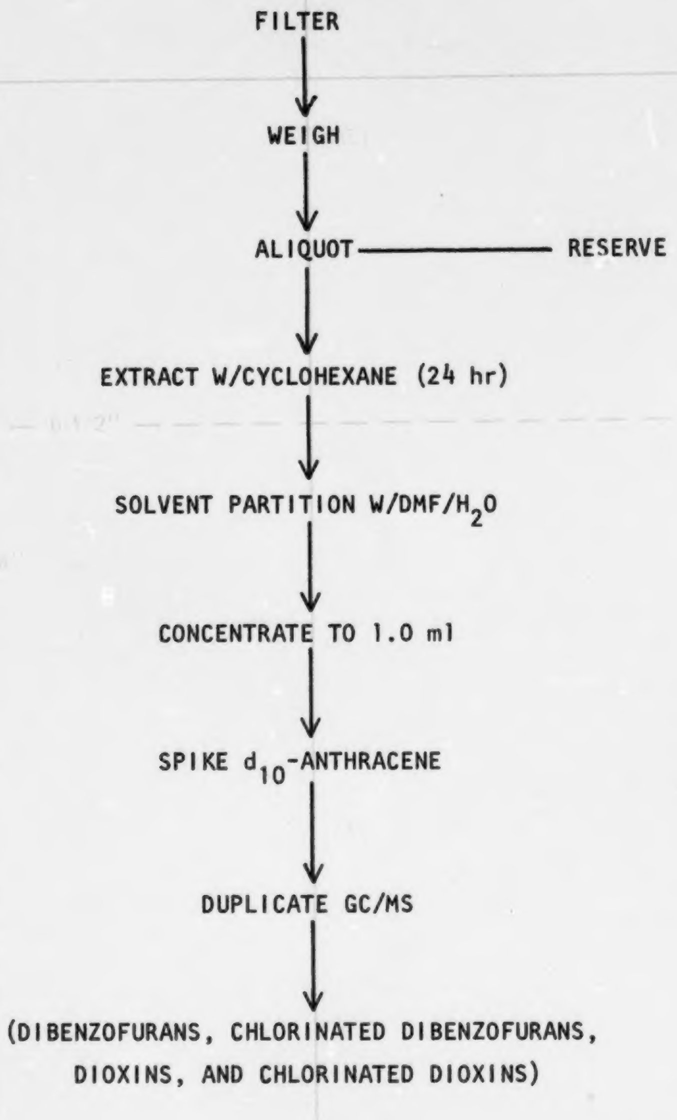

FILTER
WEIGH
ALIQUOT
RESERVE
EXTRACT W/CYCLOHEXANE (24 hr)
SOLVENT PARTITION W/DMF/H_2O
CONCENTRATE TO 1.0 ml
SPIKE d_{10}-ANTHRACENE
DUPLICATE GC/MS
(DIBENZOFURANS, CHLORINATED DIBENZOFURANS, DIOXINS, AND CHLORINATED DIOXINS)

Figure 12. Modified Method 5 train organic analysis flow scheme: particulate filters.

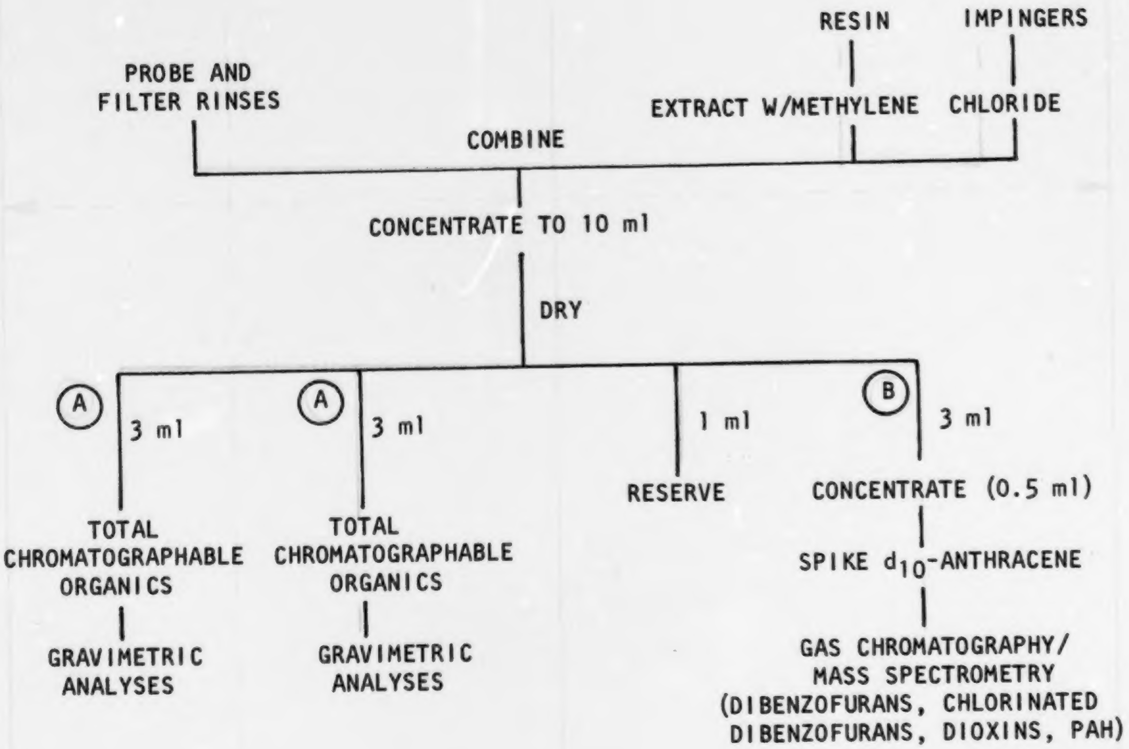

RESIN
IMPINGERS
PROBE AND FILTER RINSES
EXTRACT W/METHYLENE CHLORIDE
COMBINE
CONCENTRATE TO 10 ml
DRY
A
3 ml
A
3 ml
1 ml
B
3 ml
RESERVE
CONCENTRATE (0.5 ml)
SPIKE d10-ANTHRACENE
TOTAL CHROMATOGRAPHABLE ORGANICS
TOTAL CHROMATOGRAPHABLE ORGANICS
GRAVIMETRIC ANALYSES
GRAVIMETRIC ANALYSES
GAS CHROMATOGRAPHY/ MASS SPECTROMETRY (DIBENZOFURANS, CHLORINATED DIBENZOFURANS, DIOXINS, PAH)

Figure 13. Modified Method 5 train organic analysis flow scheme: resin.

The recovered filters were returned to the GCA laboratory for particulate analysis as outlined in Figure 12. Once particulate weights were recorded, the filter(s) were aliquotted prior to extraction. The combined filters from each sample run were soxhlet-extracted for a period of 24 hours in cyclohexane. The resultant extract then underwent a solvent exchange with a mixture of dimethylformamide/H_2O followed by back extraction into cyclohexane. The sample was then concentrated on a rotary evaporator to 1.0 ml. The extract was spiked with deuterated anthracene and scanned by means of selected ion monitoring GC/MS for chlorinated dibenzofurans and dioxins.

Dibenzofurans/Dioxins

The XAD resin was recovered from the sampling train in the field and returned to the laboratory for subsequent analyses. Figure 13 presents a flow scheme of the resin organic analysis. Each resin sample was soxhlet-extracted for a period of 24 hours with methylene chloride. The extract was combined with the probe and filter rinses and impinger extract, concentrated to a working volume of 10 ml, and dried. A 3 ml aliquot was rotary evaporated to 0.5 ml, spiked with deuterated anthracene and analyzed for the same organic compounds as the filters. The quantitative procedure proceeded as outlined earlier, by GC/MS with selected ion monitoring. The resin extract was analyzed for dibenzofurans and dioxins not absorbed on the particulates. Results of the dioxin/dibenzofuran analyses are listed in Table 3. Quality control data on the analyses is presented in Table 14.

TABLE 14. GC/MS CHARACTERISTICS OF STANDARDS FOR DIOXIN/DIBENZOFURAN ANALYSIS

Compound[a]	Retention[b] time (min)	Parent ion m/e	Secondary ion m/e
Dibenzofuran	14.9	168.1	139.1
Dibenzo-p-dioxin	15.5	184.1	128.2
2-chlorodibenzo-p-dioxin	17.7	218.0	220.1
1-chlorodibenzo-p-dioxin	17.6	218.0	220.0
2,8-dichlorodibenzofuran	19.0	236.1	238.0
2,6-dichlorodibenzo-p-dioxin	19.5	252.0	254.0
1,2,4-trichlorodibenzo-p-dioxin	21.2	288.0	286.0
1,2,3,4-tetrachlorodibenzo-p-dioxin	23.0	322.0	320.0
D_{10} anthracene	18.0	188.2	--

[a] Detection Limit: 0.5 ng/µl

[b] GC/MS Instrumental Parameters - Table A-6.

The 7 ml remainder of the XAD extract was aliquotted into a 1 ml reserve and two 3 ml portions for assessment of total organic residues (see Figure 13). The latter analyses consisted of total chromatographable organic (TCO) and gravimetric analyses.

Organics

Chemical analysis of moderately volatile organic materials (B.P. 100°-300°C was accomplished by gas chromatography coupled with flame ionization detection. A summary of instrument operating conditions is presented in Table A-5. This technique is designed to provide both qualitative and quantitative information on appropriate sample extracts. The qualitative analysis divides each sample into discrete boiling point ranges, which are defined by a mixture of n-alkanes (C_7-C_{17}). This is accomplished through the use of retention time data recorded for standard mixtures of these materials.

Retention time window calibration of the procedure was accomplished by the injection of a mixture of the normal hydrocarbons C_7 through C_{17} (B.P. 100°-300°C). Quantitative calibration was based on the integration of detector response to known concentrations of normal C_8, C_{12} and C_{16} hydrocarbons. Retention times and integrated peak areas were measured using a Hewlett-Packard Model 3380S Integrator.

The purpose of the gravimetric analysis is to quantify organic constituents with boiling points greater than 300°C. Typical analyses consist of pipetting a 1.0 ml aliquot of each 10.0 sample extract into a precleaned and tared aluminum weighing pan. After a period of sample desiccation, to remove residual solvent, each sample is weighed to a constant weight of ± 0.1 mg. Gravimetric determinations were accomplished by use of a Mettler ME-22 Electronic Microbalance.

The total chromatographable or volatile organics (TCO) results reported in Table 15 have been corrected by subtracting the integrated area response to field-biased component blank extracts for the EPA Modified Method 5 train resin and rinses. The corrected TCO results correspond to the total quantity of organic material in the 100° to 300°C boiler range not collected on the EPA Method 5 train particulate filter.

TABLE 15. ORGANIC EMISSIONS USING MODIFIED EPA METHOD 5 SAMPLING TRAIN (IMPINGER EXTRACT/RINSE EXTRACT/TRAIN RINSES)

	Test day		
	No PCB in fuel	PCB burn day 1	PCB burn day 3
Total Chromatographable (volatile) Organics, (TCO) (μg/m^3)	33.2	54.2	35.6
Nonvolatile Organics Grav. (μg/m^3)	667	678	842
Total Organics (μg/m^3)	700	732	877

The gravimetric results reported in Table 15 have been corrected by subtracting the gravimetric weight of field-biased component blank extracts for the EPA Modified Method 5 train resin and rinses. The corrected gravimetric result quantitates the organic sample components with boiling points higher than 300°C which were not collected on the particulate filter of the sampling train.

Chloride

The chloride analyses of the sodium carbonate impingers were accomplished with a Dionex Model 14 Ion Chromatograph. The column system employed: (1) a pre-column (3 x 150 mm) to remove particulates, strongly retained anions, and organic species; (2) a separator column (3 x 500 mm) in the HCO_3- form to chromatographically separate the anions, and (3) a suppressor column (5 x 250 mm) in the H^+ form to remove the background conductivity of the eluent. A solution of 0.003 M $NaHCO_3$/0.0024 M Na_2CO_3 was issued for the eluent at a 30 percent flow rate (about 140 ml/hr). The injection loop had a capacity of 100 µl and the sample was introduced from a 5 ml disposable syringe fitted with a 0.22 µm Millipore filter to remove particulate matter.

The height of the chloride peak was measured and converted to the appropriate concentration by comparison with standard solutions. The chloride concentrations in the standards ranged from 0.2 to 20 ppm. A 3 x 500 mm separator column was used to separate the chloride peak from the anionic impurities in the sodium carbonate impinger solution.

The results from the first impinger analysis have been aliquot corrected. Correction for blank contributions was unnecessary because both the distilled water and the $Na_2CO_3(aq)$ preservative contains no measurable chloride (0.2 g/ml). Results of the analysis are listed in Table 16.

TABLE 16. METHOD 5 TRAIN CHLORIDE ANALYSIS

Run number	1st impinger (mg)	2nd and 3rd impingers (mg)	Chloride (mg)	VMSTD[a] (m^3)	$\mu g/m^3$ cl
M-5-1	19	2	21	4.808	4,000
M-5-2	231	3	234	5.446	43,000
M-5-3	sample lost	7		3.290	

[a] VMSTD = Volume of gas sample through the dry gas meter (corrected to standard conditions).

The chloride analyses was performed in an attempt to measure the relative contribution of PCBs to stack chloride emissions. However, the test results were inconclusive. As indicated in Table 16, the background (no PCB) test run, M-5-1, had a measurable chloride emission of 4000 µg/m^3. The initial PCB run, M-5-2, showed greater than a tenfold increase over this background value. While all of this increase might appear to be attributable to chlorine from PCB destruction, a closer examination of the chlorine input values tends to discount this assumption. The chlorine content of the residual oil used for the test was measured to be 0.97 percent, or 9700 ppm, as shown in Appendix G. The maximum PCB concentration of the input fuel stream on test day 2 was 72 ppm, as shown in Table 4. If one assumes that the PCB utilized during the test was Aroclor 1242, then three equivalent weights of chlorine are liberated per weight of PCB destroyed, as shown in Table 12. The net contribution of PCB to overall chlorine emissions would therefore be expected to be minimal. The tenfold increase in chloride concentration resulting from the PCB burn cannot be fully explained. Interferences with background organic substances may have led to false chloride peaks on the Ion Chromatograph, which were interpreted to be chloride. Unfortunately, the chloride sample for run number M-5-3 was lost so a confirmation of the tenfold chloride increase could not be substantiated and a statistically significant relationship between PCB destruction and chloride emissions could not be established.

Particulate

The recovered Method 5 sampling train filters were returned to the GCA laboratory for analysis as outlined in the test plan.[4] Once particulate weights had been recorded, the filter(s) were aliquotted prior to extraction. The combined filters from each sample run were soxhlet-extracted for a period of 24 hours in cyclohexane. The resultant extract was solvent exchanged with a mixture of dimethylformamide/H_2O followed by back extraction into cyclohexane. Prior to concentration, each extract was passed through a column of anhydrous sodium sulfate. Each sample was concentrated on a rotary evaporator to 1.0 ml. Extracts were spiked with deuterated anthracene and scanned by means of selected ion monitoring GC/MS for the compounds listed in Table 14. The GC/MS instrument parameters are shown in Appendix A, Table A-6.

The pH of the impinger water samples was adjusted first to 2.0, then to 12 for duplicate extractions (3 at each pH) with 20 percent (V:V) portions of dichloromethane. The extracts were held for combination with the XAD extract and train rinses.

Particulate Weight

Particulate filters were not available for particulate weight determination in two of three Modified EPA Method 5 runs, Table 17. This is contrary to the original test plan for the following reason: after the respective run, particulate filters were wrapped in hexane rinsed aluminum foil, and stored in glass petri dishes. The filters were found adhered to the aluminum foil, making a complete weight determination virtually impossible without adversely affecting the TCO determination. The assumption was then made that, with steady-state boiler operation and visibly similar particulate loadings, the one particulate filter would be representative of the particulate weight in the two other runs.

TABLE 17. PARTICULATE WEIGHT

Run	Particulate weight (mg)	Particulate concentration	
		(gr/dscf)[a]	(lb/hr)
M-5-1	89.47	0.0081	0.0658
M-5-2	Not available	→	→
M-5-2	Not available	→	→

[a] gr/dscf = grams per dry standard cubic foot.

IN-PLANT PCB ANALYSIS

The analytical techniques used were those prescribed by the National Institute for Occupational Safety and Health[1] (P&CAM No. 253, see Appendix C). Approximately 350 milligrams of Florisil were packed into each glass sampling tube to capture airborne PCBs by means of adsorption. All tests showed nondetectable levels of PCB which indicates that concentrations were less than 3 $\mu g/m^3$ and 12 $\mu g/m^3$ for Aroclor 1242 and Aroclor 1254, respectively. The results are given in Appendix J.

PCB BLOOD CHEMISTRY ANALYSIS

The blood samples were split and analyzed by the State of Michigan Department of Health Laboratory in Lansing, Michigan and the Raltech Laboratory in Madison, Wisconsin. The results are given in Appendix L. The results showed that, within the limits of accuracy of the testing, there were no significant changes in the preburn and post-burn PCB blood samples of the GM powerhouse operators. Furthermore, the PCB blood levels of these operators was comparable to the GM office employees with the least exposure to environmental PCB.

BOILER PCB RESIDUAL ANALYSIS

The analytical technique used to detect PCBs in the boiler residual samples (solid bulk material or scrapings) is outlined in Appendix D. The results, which are given in Appendix K, indicate that, except for an expected buildup around the burner tips, (1) the readings were either close to or below the nondetectable levels, and (2) no significant buildup was occurring.

FUEL ANALYSIS

The waste oil, spiked oil, and mixed oil samples were analyzed by several laboratories. The analytical procedures used by Chevrolet Central Office and Chevrolet Bay City laboratories are referenced in Appendix E. The procedures used by Trace Elements Inc. and Phoenix Chemical Laboratories Inc. are referenced in Appendices H and I, respectively. The results are given in Appendix G.

GCA's fuel analysis procedures can be differentiated by the type of analysis performed. For the PCB analysis, fuel oil sample bottles were heated at 40°C in a water bath and stirred for 1 minute prior to aliquotting to ensure sample homogeneity.

A 0.5 g portion of each sample was transferred to a clean, pretared 5.0 ml volumetric flask. The flask was reweighed and the sample diluted to 5.0 ml. The well-mixed sample was removed to a clean, 10 ml vial containing 5.0 ml of concentrated sulfuric acid for cleanup per the procedure cited in the Federal Register, May 31, 1979 (40 CFR 761). The oil/acid phases were mixed and the oil fraction quantitatively transferred to a clean vial containing 5.0 ml of 10 percent $NaHCO_3$ (aq). A portion of the oil fraction was then transferred to a septum vial for analysis by GC/ECD using the instrument parameters detailed in Table A-3.

Qualitative identifications and quantitations were performed according to the procedures outlined for ambient analyses. Results of these analyses are shown in Table 1.

For the dibenzofuran/dioxin analysis, fuel oil sample bottles were heated to 40°C in a water bath and stirred for 1 minute prior to aliquotting to ensure sample homogeneity.

A 1.0 g portion of each sample was transferred to a clean, pretared 5.0 ml volumetric flask. The flask was reweighed and the sample diluted to 5.0 ml with dichloromethane. GC/MS analyses were performed as indicated in Table 14 and Table A-6 in Appendix A.

A summary of the waste oil analysis is presented in Appendix G. A discussion of the waste oil data is given in Appendix N. These data indicate that, apart from the variation in interlaboratory fuel oil PCB measurements disucssion in Section 7, the residual oil used in the test series contained no unusual or atypical concentration of any metallic or organic species that would tend to affect the destruction efficiency results.

AMBIENT PCB ANALYSIS

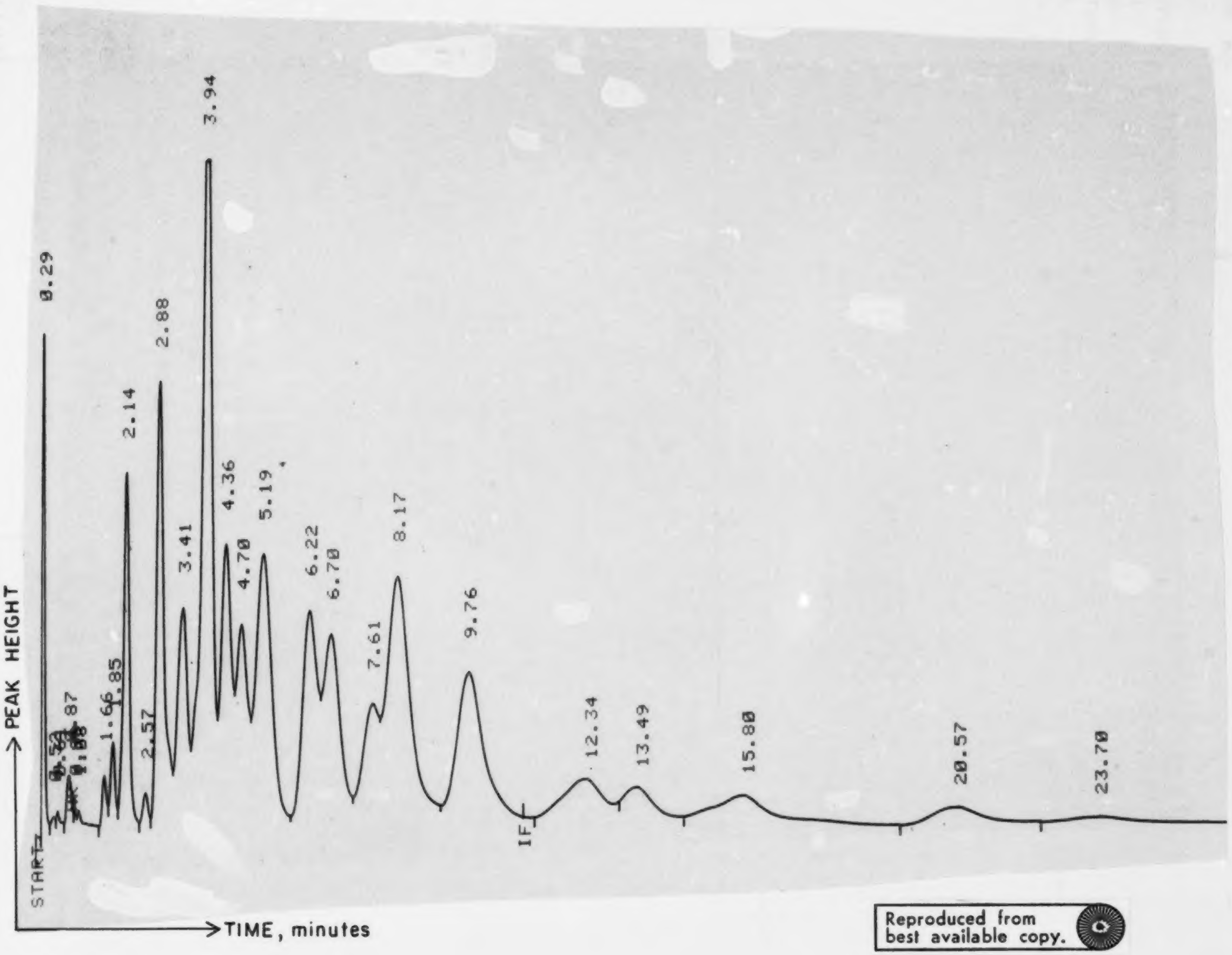
Polyurethane foam plugs and Hi-Vol filters were collected from ambient monitors and returned to the laboratory in precleaned amber glass jars with Teflon-lined caps. The samples were combined as necessary and soxhlet extracted overnight with hexane. After cooling, the extracts were transferred to round bottom flasks and the volume reduced to 2 ml via rotary evaporation. The extract was then divided into a reserve plus a portion for GC/ED analysis of PCB. A 0.5 ml aliquot was subjected to alumina cleanup as recommended in "Sources of Emissions of Polychlorinated Biphenyls in Ambient Atmosphere and Indoor Air."[10] Each extract was further cleaned by extraction with concentrated sulfuric acid and analyzed using the instrumental parameters listed in Table A-1.

Qualitative identification of PCB was performed using the Aroclor pattern-matching technique. Instrument calibration was accomplished by injection of 0.2, 2.0 and 10.0 ppm (g/ml) dilutions of an Aroclor 1242 standard prepared in hexane. These dilutions were prepared from a commercially available stock solution distribution by Applied Science Labs, Inc., State College, Pa. Calibration was checked every sixth sample to ensure a uniform detector response. Figure 14 is a typical Aroclor 1242 standard chromatogram. The retention times of the five peaks used for area summation calibration were 2.92, 3.95, 5.20, 6.73, and 9.80 minutes.

Calibration curves were prepared daily from a linear regression analysis of the above three Aroclor dilutions. Each of these data points was obtained by the summation of five appropriate peak areas.

Calibration curves were rejected if the correlation coefficient of the linear regression analyses was less than 0.996. All samples were quantitated by entering the area summation into the appropriate calibration curve. Sample extracts were diluted, if necessary, to be within the concentrations bracketed by the calibration standards.

Results of GC/ECD analyses of ambient PCB samples are listed in Table 5. A typical sample chromatogram of the extract derived from 1 day's ambient sample is shown in Figure 15.



Reproduced from best available copy.

Figure 14. GC/ECD Chromatogram of Aroclor 1242 Standard.

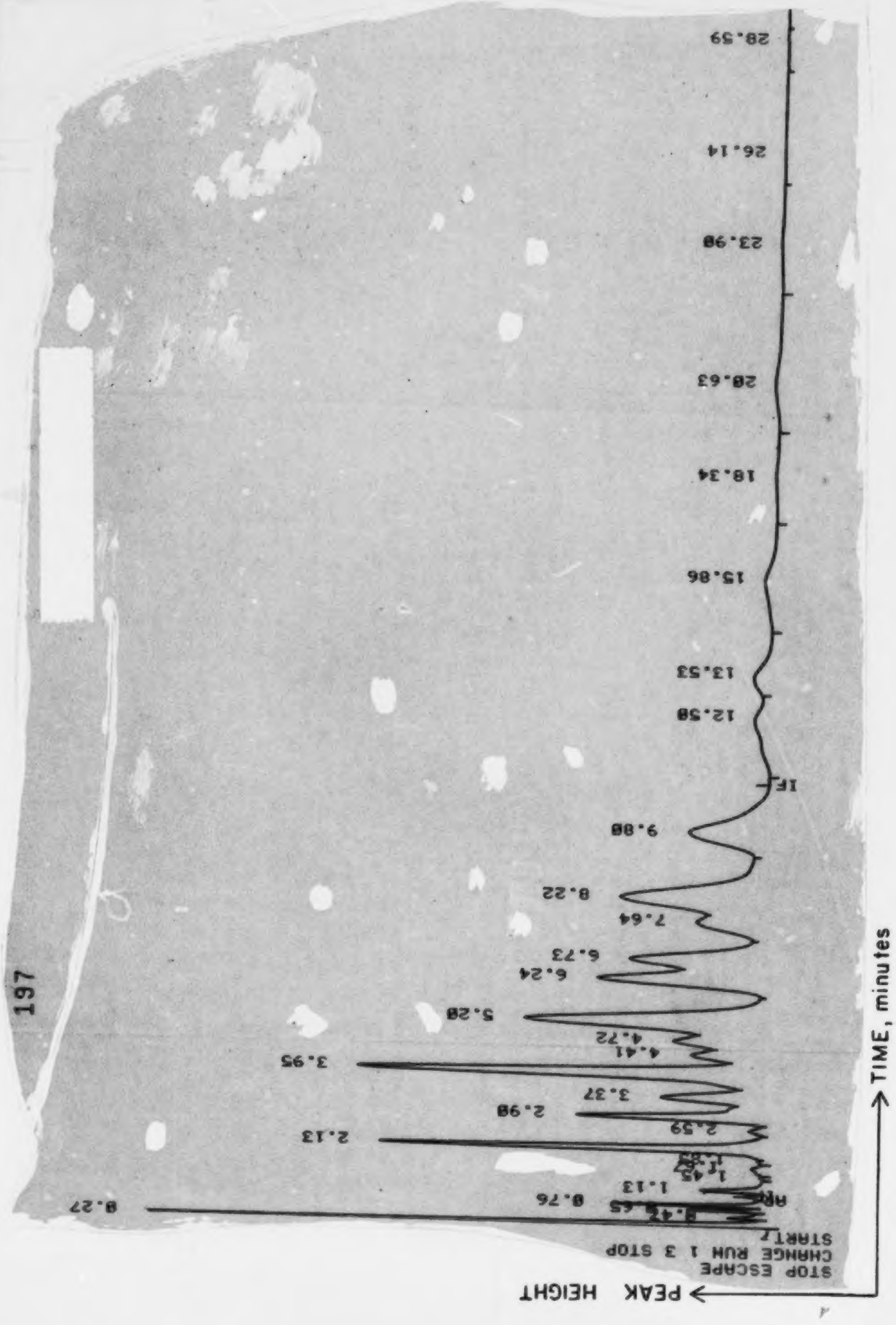


Figure 15. GC/ECD chromatogram of day 1--downwind site 1--preburn.

SECTION 6

AIR QUALITY MODEL CALCULATIONS

The rural version of the RAM Gaussian plume model[7] developed by the EPA Meteorology Laboratory was used to calculate the average PCB concentration fields downwind from the facility during the three test periods. This version of the model is based on algorithms similar to those used in CRSTER.[7] It is designed for application to one or several days of meteorology rather than a full year. Plume rise is calculated by the Briggs equations.[7] The requisite model input parameters were developed from stack test data and hourly onsite meteorological measurements.

In carrying out the model calculations, receptors were located to ensure area coverage sufficient to define the approximate location and magnitude of the highest concentration. Multiple model runs were carried out. One run was carried out for each trial to define the concentration field that would be expected at a height of 2 m in the absence of building structures. Additional runs were made to determine concentrations expected at monitors located at other heights.

Table 18 lists the meteorological and source parameters used in the model calculations. Table 19 shows the monitor locations with reference to the boiler stack during each test day, and Table 20 gives the heights of the monitors above ground.

Figures 16 through 19 are combined plots showing the locations of the monitors and the prevailing wind direction on each of the four test days. In these figures wind direction percentages are indicated by vectors originating at the boiler and flowing with the wind. In Figure 16, the vectors represent winds during the entire test day prior to any PCB burn. On days with a PCB burn (Figures 17, 18, and 19), however, the vectors represent winds during the period of the burn only. As can be seen from Figures 17 through 19, placement of the ambient monitors to measure expected maximum PCB concentrations during burn days was generally good. Burn number 3 had the best overall monitor placement, with monitor 2 located directly downwind of the principal wind direction, as shown in Figure 19. All downwind monitors were within 30 compass degrees of the prevalent wind direction during burn number 1 (Figure 17). Only during burn number 2 (Figure 18) were the three downwind monitors as much as 30 to 60 compass degrees from the true wind direction for the burn period.

Figures 20, 21, and 22 show the 2m concentration isopleths predicted by the model for each of the PCB burns. Maximum impact of the boiler during these test burns at ground level (2 meters) is of the order of 7-10 x 10^{-3}

TABLE 18. MODEL INPUT PARAMETERS FOR PCB BURNS

Test day	Date	Period	Exit velocity (m/sec)	Stack temp. (^{o}C)	Wind direction (deg)	Wind speed (m/sec)	Stability class
2	5/08/80	1430-1530	8.5	129	305	5.6	C
		1530-1630	8.5	129	305	6.0	C
		1630-1730	8.5	129	285	6.0	D
		1730-1830	8.5	129	290	5.6	D
		1830-1930	8.5	129	300	5.4	D
		1930-2030	8.5	129	305	4.2	D
3	5/09/80	1300-1400	9.3	132	260	5.6	C
		1400-1500	9.3	132	240	6.0	C
		1500-1600	9.3	132	240	5.6	C
		1600-1700	9.3	132	240	5.4	D
		1700-1800	9.3	132	255	4.2	D
		1800-1900	9.3	132	260	3.8	D
4	5/10/80	1400-1500	7.1	116	210	9.8	D
		1500-1600	7.1	116	205	8.3	D
		1600-1700	7.1	116	190	5.6	D
		1700-1800	7.1	116	185	5.8	D
		1800-1900	7.1	116	170	6.0	D
		Stack height (above ground)			18.3 m		
		Stack diameter			1.07 m		
		Assumed source strength			1.0×10^{-6} g/sec		

TABLE 19. LOCATION OF MONITORS DURING TEST PERIODS

Test day	Site identification							
	1		2		3		4	
	x(m)	y(m)	x(m)	y(m)	x(m)	y(m)	x(m)	y(m)
1	-91	-96	76	84	133	126	553	503
2	-82	52	238	-24	254	-20	445	-198
3	-82	52	238	-24	254	-20	445	-198
4	-91	-96	49	258	201	805	402	872

Note: Origin of coordinate system is at boiler stack.

TABLE 20. MONITOR HEIGHTS DURING TEST PERIODS

Test day	Height (m)			
	Site identification			
	1	2	3	4
1	2.3	1.0	1.0	2.0
2	2.3	8.9	8.9	2.0
3	2.3	8.9	8.9	2.0
4	2.3	1.0	1.0	2.0

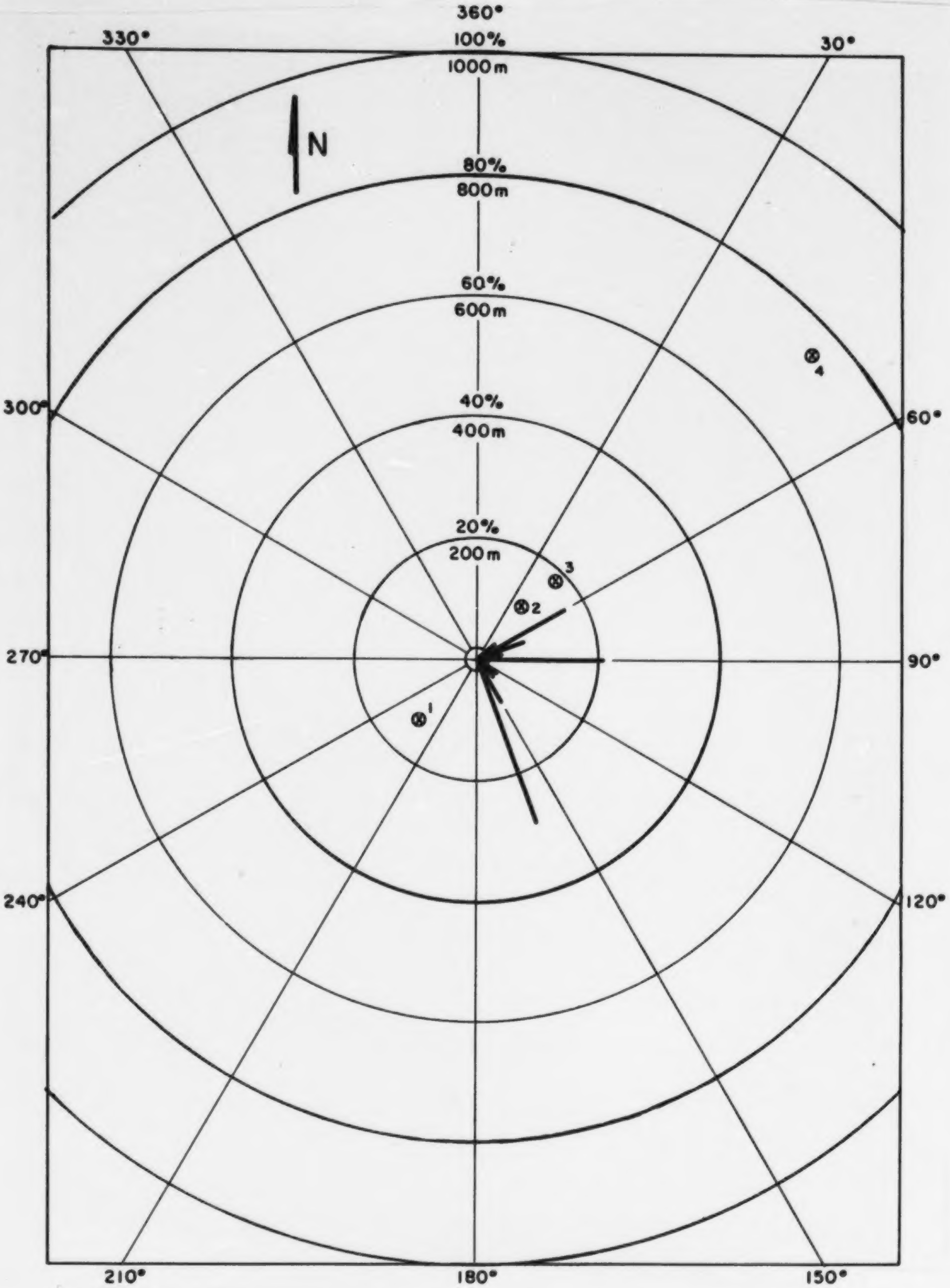


Figure 16. Locations of monitors and flow direction vectors during test day 1 (no burn).

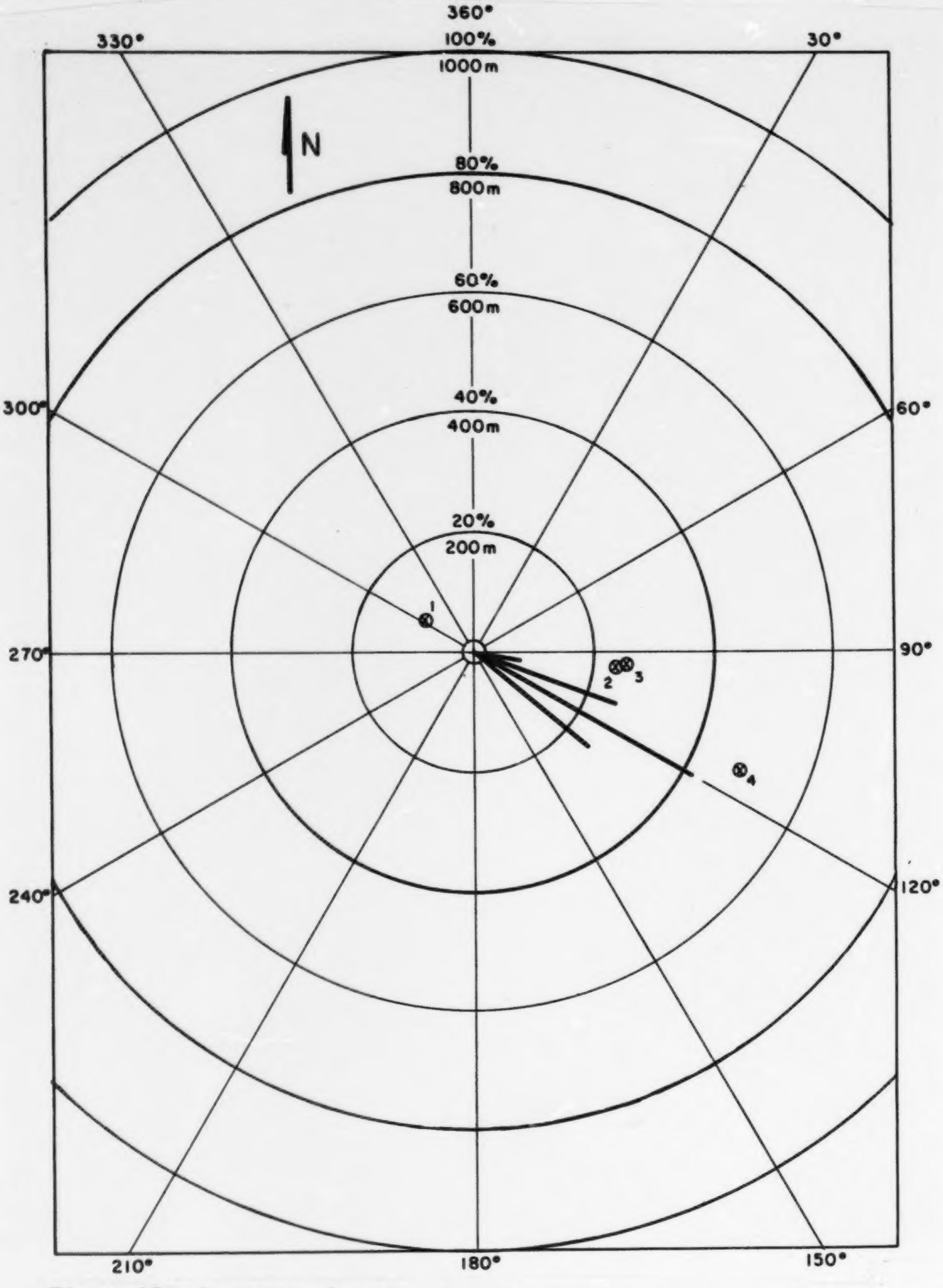


Figure 17. Location of monitoring and wind direction rose during burn No. 1 (test day 2).

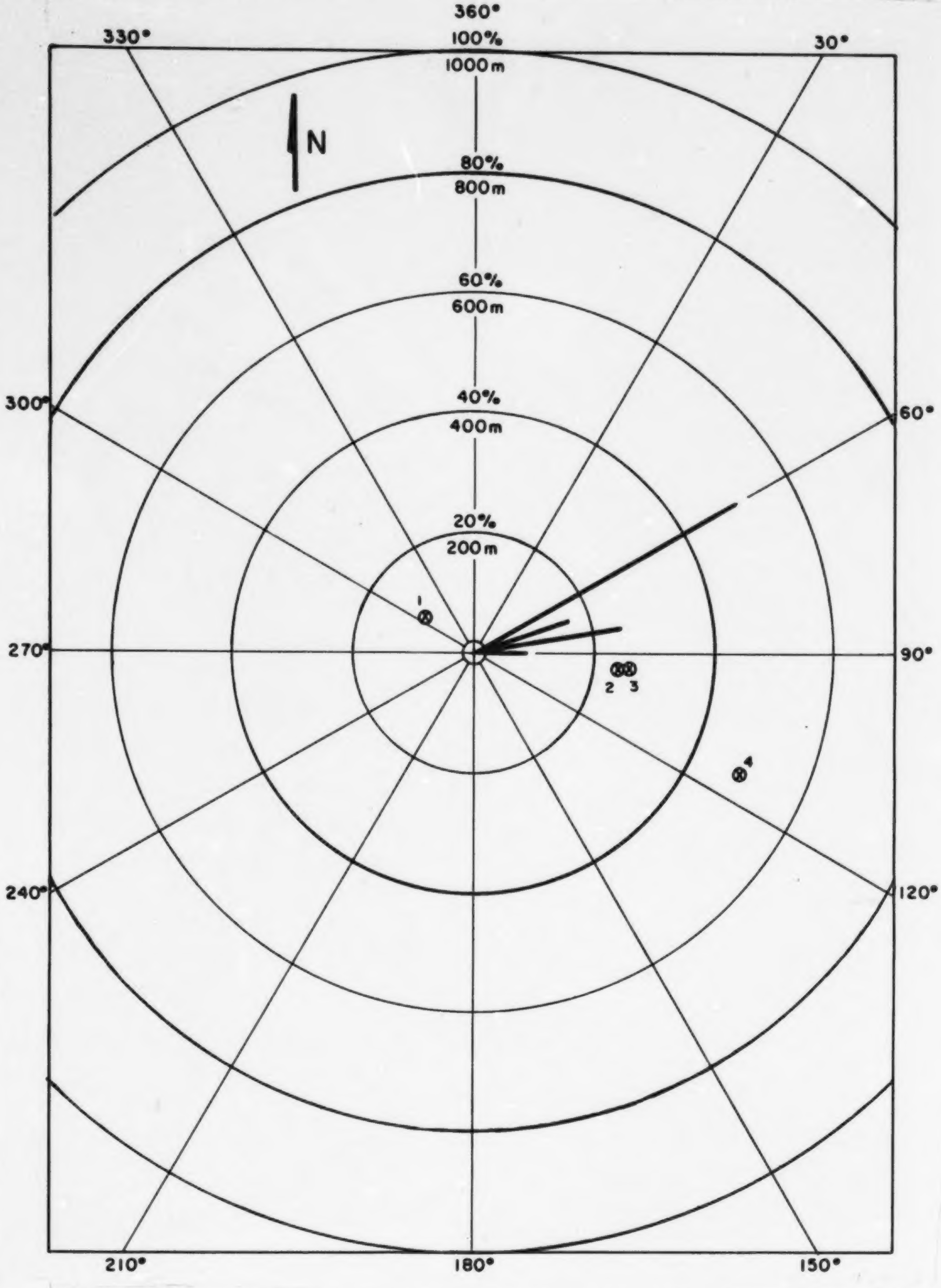


Figure 18. Location of monitors and wind direction rose during burn No. 2 (test day 3).

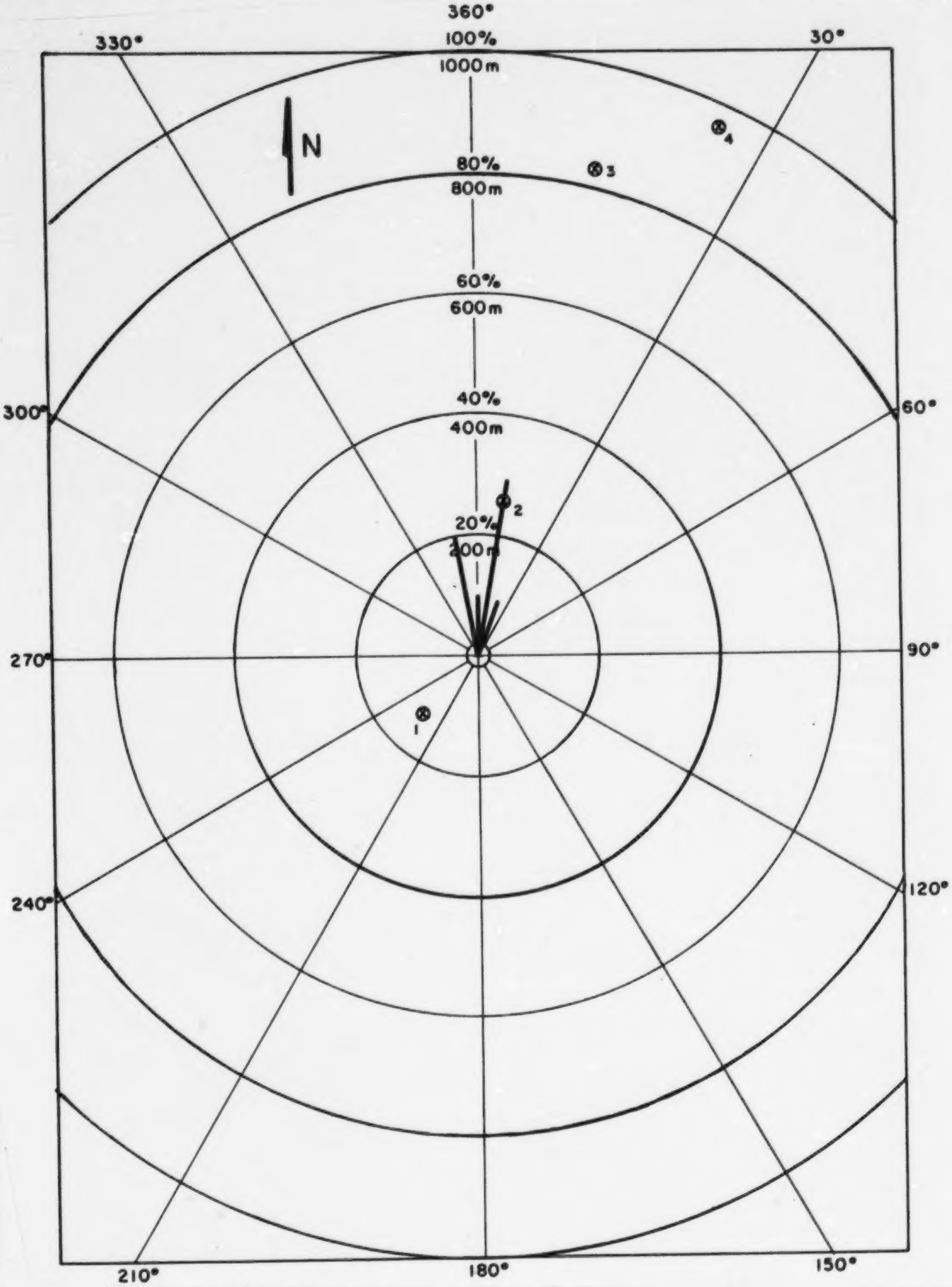


Figure 19. Location of monitors and wind direction rose during burn No. 3 (test day 4).

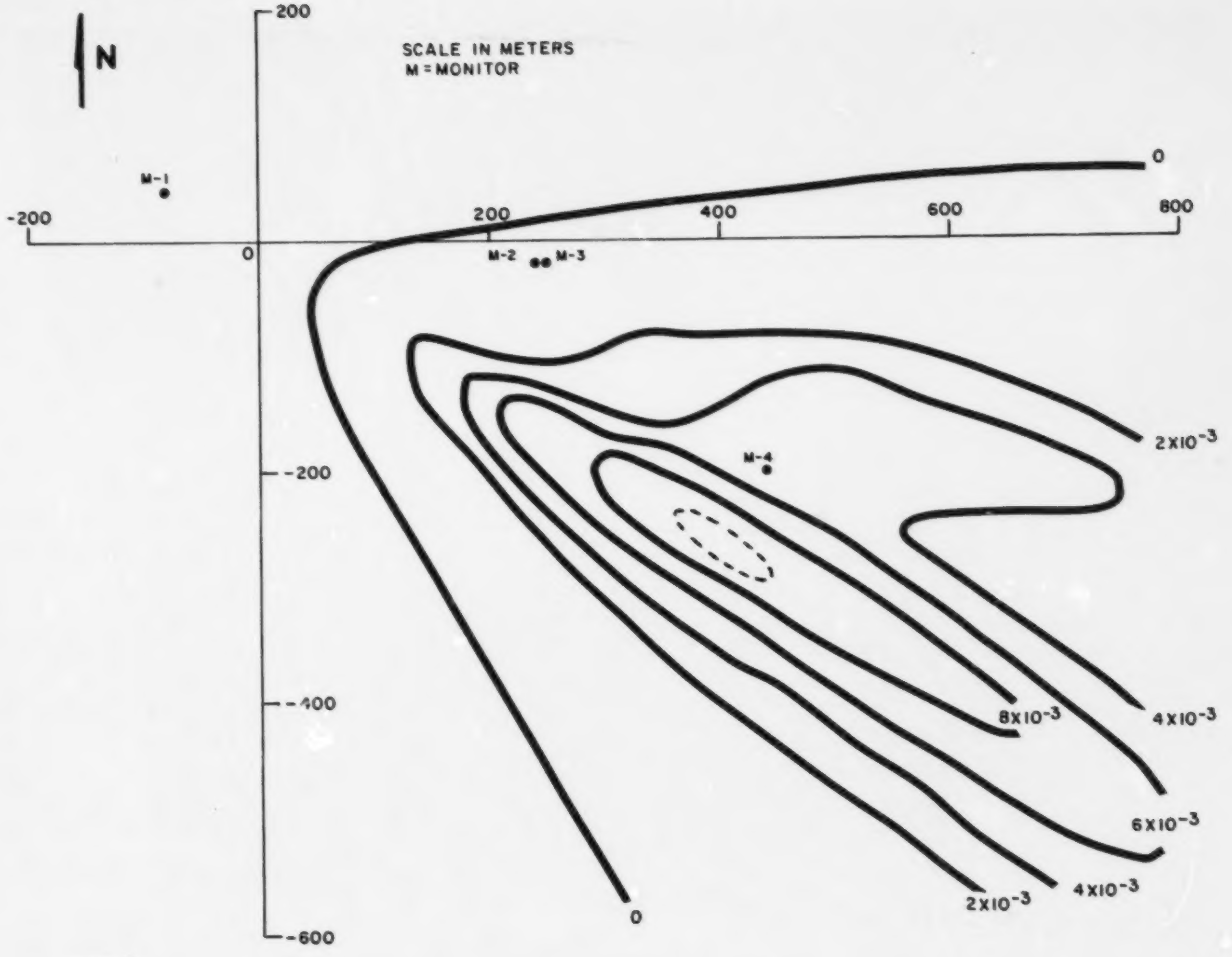

N
SCALE IN METERS
M=MONITOR
M-1
M-2
M-3
M-4
-200
0
200
400
600
800
-200
-400
-600
0
2X10^{-3}
4X10^{-3}
6X10^{-3}
8X10^{-3}
4X10^{-3}
2X10^{-3}
0

Figure 20. Predicted facility impact on PCB concentration field during burn No. 1 (test day 2). (Distance scale is in meters, concentration isopleths are in ng/m^3, M designates a monitor).

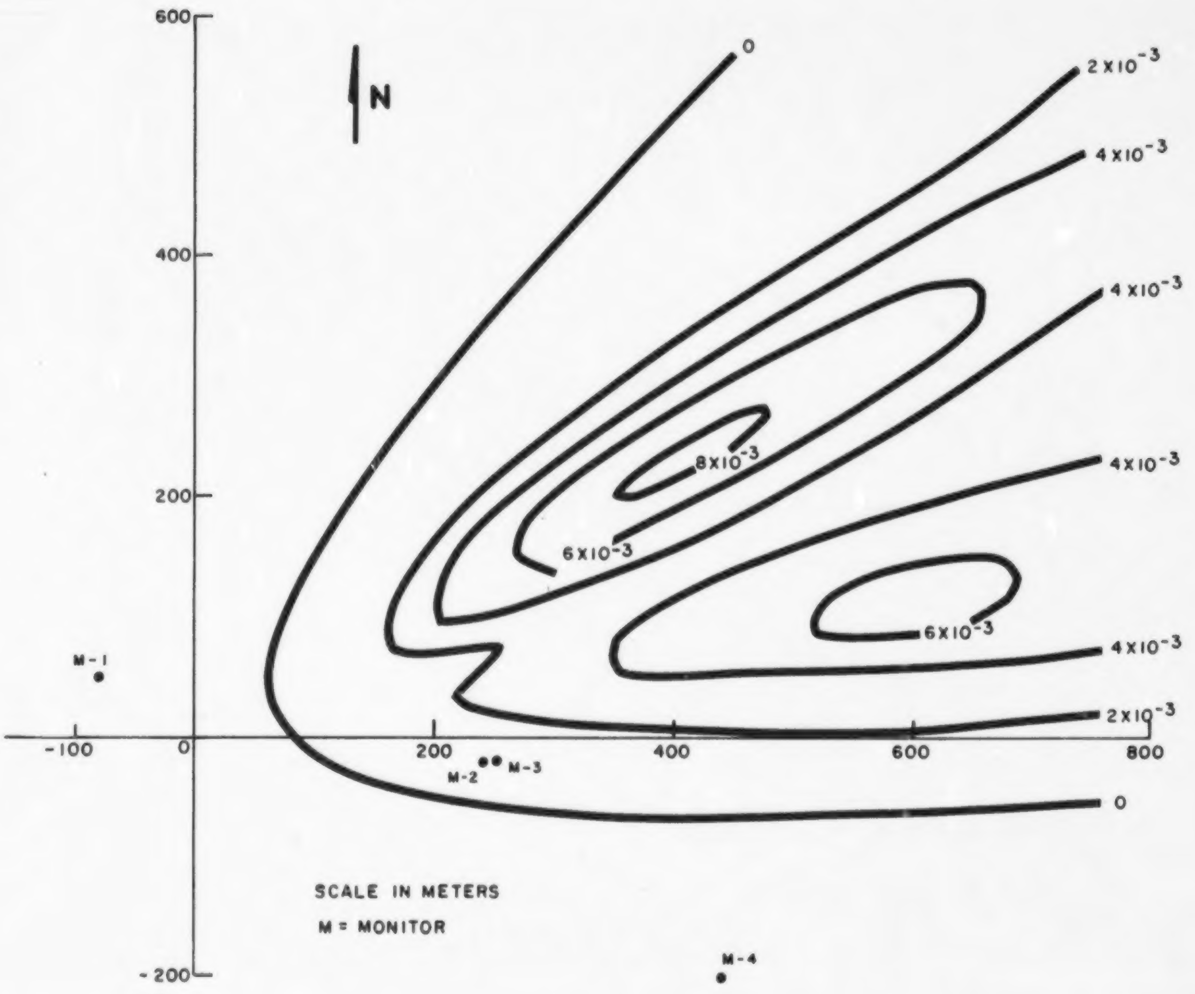


Figure 21. Predicted facility impact on PCB concentration field during burn No. 2 (test day 3). (Distance scale is in meters, concentration isopleths are in ng/m^3, M designates a monitor).

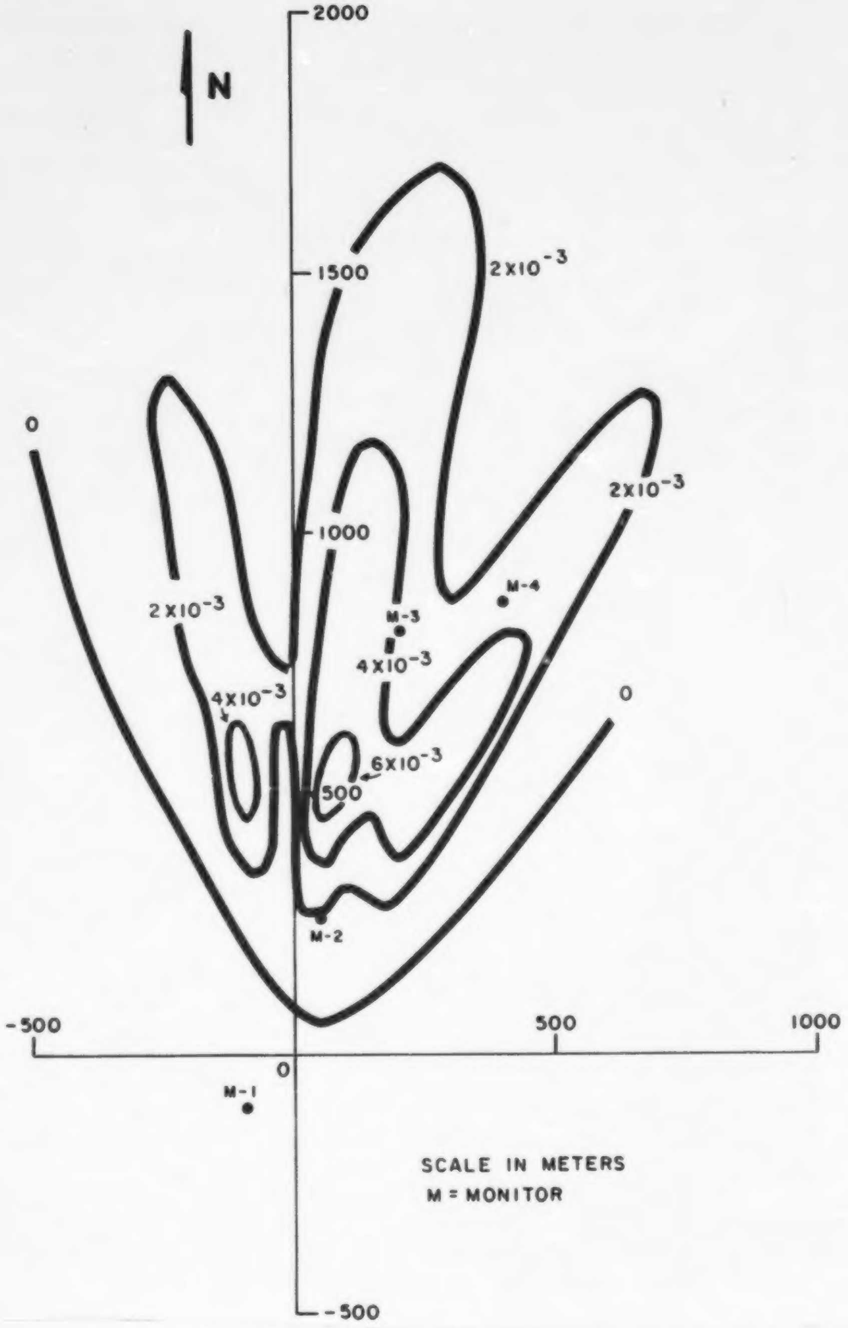

N
2000
1500
1000
500
-500
0
-500
500
1000
0
0
2X10^-3
2X10^-3
2X10^-3
4X10^-3
4X10^-3
6X10^-3
M-1
M-2
M-3
M-4
SCALE IN METERS
M = MONITOR

Figure 22. Predicted facility impact on PCB concentration field during burn No. 3 (test day 4). (Distance scale is in meters, concentration isopleths are in ng/m^3, M designates a monitor).

ng/m^3. These estimates are based on a source strength of 1×10^{-6} g/sec PCB, which is the indicated upper limit of possible source strengths during the test burns. (Stack sampling indicated source strengths less than 9.7×10^{-7} g/sec). It can be seen from these figures that the monitors were satisfactorily positioned except for Test Day 3 (Burn No. 2) when little, if any, of the boiler plume impacted on any of the monitors. This unsatisfactory monitor placement for Test Day 3 can also be seen in the wind rose plot for this day, Figure 18.

Table 21 compares the maximum expected boiler impact during the various trials with the observed ambient concentrations. The results are striking. In every case the observed concentrations greatly exceed the values predicted by the model, differing, on the average, by about 5 orders of magnitude. Thus, even allowing for modeling error, it is quite clear that the impact of the boiler upon the existing ambient PCB levels is insignificant. This is in agreement with the statistical analysis presented in Table R-1, Appendix R, where upwind and "no-burn" concentrations are compared with downwind "burn" concentrations.

It is also of interest to compare the stack concentration of PCB during the test burns with ambient concentrations. Assuming a PCB emission rate of 1×10^{-6} g/sec yields stack concentrations ranging from about 120 to 160 ng/m^3 during the various burns. This is less than the average of the 20 ambient samples (203 ng/m^3) collected at upwind locations and during no burn periods. How much lower the actual stack concentration was than the assumed 1×10^{-6} g/sec is not known because of limitations in the sampling procedure.

Table 22 gives the wind direction distributions for the various sampling periods. Examination of these distributions in conjunction with the observed concentrations (Table 5) shows the following feature of note. The highest concentrations of all (1400 and 500 ng/m^3) were observed at Sites 2 and 3 on Test Day No. 1 prior to conducting any PCB incineration. During this period winds were from the southwest (230-250 degrees). When the wind shifted to 340 degrees the concentrations dropped dramatically to 50 and 15 ng/m^3, respectively at the two sites. This behavior is suggestive of a PCB source(s) to the southwest of the monitors.

TABLE 21. COMPARISON OF MAXIMUM EXPECTED FACILITY IMPACT AND OBSERVED CONCENTRATION OF PCB

Test day	Site identification							
	Upwind--1		2		3		Population--4	
	Max. exp.	Obs.	Max. exp.	Obs.	Max. exp.	Obs.	Max. exp.	Obs.
1	-	1.9×10^2	-	4.3×10^2	-	2.9×10^2	-	0.63×10^2
2	-	3.5×10^2	0.19×10^{-3}	0.84×10^2	0.11×10^{-3}	0.82×10^2	4.21×10^{-3}	0.67×10^2
3	-	3.9×10^2	0.17×10^{-3}	0.45×10^2	0.29×10^{-3}	0.55×10^2	0	0.28×10^2
4	-	1.2×10^2	1.80×10^{-3}	1.3×10^2	2.56×10^{-3}	0.26×10^2	3.39×10^{-3}	0.51×10^2

Notes: Concentrations are in ng/m^3.

Concentrations are for entire sampling day at Sites 1 and 4; for Sites 2 and 3, concentrations are for period of burn only.

TABLE 22. DISTRIBUTION OF WIND DIRECTION DURING VARIOUS SAMPLING PERIODS

Wind[a] direction (deg)	Test day 1				Test day 2				Test day 3				Test day 4			
	"Pre-burn"	"Burn"	"Post-burn"	Total	"Pre-burn"	"Burn"	"Post-burn"	Total	"Pre-burn"	"Burn"	"Post-burn"	Total	"Pre-burn"	"Burn"	"Post-burn"	Total
160											2	2				
170														2		2
180														1		1
190											1	1		3		3
200													1	1		2
210													5	3		8
220											1	1				
230	1			1												
240	4			4						6	1	7				
250	1	1		2						2		2				
260		1		1					3	3	1	7				
270		5		5					3	1		4				
280						1	2	3								
290					1	3		3								
300					1	5	1	7								
310		1		1	2	3		5								
320		1		1	2		1	3								
330		2		2			1	1								
340		1	6	7												

[a] Degrees indicate direction from which the wind is blowing based on 30 minute averages.

Note: Observations are 30-minute averages.

SECTION 7

QUALITY ASSURANCE/QUALITY CONTROL

As designated in the program test plan, a detailed quality control program was conducted throughout the course of the sampling and analysis effort. The primary elements of the program are highlighted below.

QUALITY ASSURANCE PROTOCOL

Quality assurance audits were conducted during the course of the program. These included reviews of field and laboratory test data, notebooks, and standard operating parameters, in addition to periodic reviews of program quality control data. The results of these audits, fortified further the quality of sampling and analysis data. The tests of these audits are on file with the contractor for this report.

INVESTIGATIVE ACTIONS

Investigative actions initiated during the program were prompted by interlaboratory data discrepancies in the reclaim waste oil analysis. As shown in Table 4, the GM and GCA analyses for fuel oil PCB concentrations varied considerably. To ascertain the cause of this discrepancy, EPA assigned Research Triangle Institute (RTI) to conduct a program audit of GCA and GM data, Quality Assurance/Quality Control (QA/QC) procedures and recordkeeping and procedural documentation related to the sampling of the test burn oil. These findings are reported in a companion report.[2] RTI found that the differences among the GM and GCA laboratories appear to represent the analytical variability that is inherent in the analysis for complex mixtures containing PCBs. A complete documentation of the fuel oil sampling and analysis procedures followed by GCA is provided in Appendix N.

QUALITY CONTROL PROCEDURES

The quality control program consisted of the following: (a) detailed quality control acceptance criteria for all reagents, solvents, and adsorbent media utilized during the course of the program, (b) quality control of analytical procedures, including collection and analysis of appropriate method blank, and (c) validation of analytical quality.

Reagent Quality Control Criteria

Acceptance criteria were implemented for all reagents, solvents, and adsorbent media utilized in the program. The Laboratory Analysis Department of GCA routinely monitors all solvents for gravimetric residues and chromatographic interferences (GC/FID). Each of these measurements were collected for the solvents utilized on this program including methylene chloride, hexane and acetone. Where appropriate, electron capture acceptance criteria were implemented to quantitate potential interferences in all GC/ECD measurements; e.g., PCBs.

Preparatory cleanup procedures were used on all adsorbent media including solvent extraction and conditioning of all Florisil, polyurethane foam plugs and XAD-2. Acceptance criteria established for each of these media were met prior to distribution for field use.

Quality Control Criteria for Blanks

The quality control program required pretest analysis of all solvents, reagents and sample media for possible interference via the proposed analytical method. The criteria for quality assessment are summarized in Table 23.

TABLE 23. QUALITY CONTROL CRITERIA/BLANKS

Matrix	Analysis procedure	Criterion for evaluation	Number of samples
Hexane (DIG)	GC/ECD	<1.0 μg/l Aroclor 1242	2
Acetone (DIG)	GC/ECD	<1.0 μg/l Aroclor 1242	2
Florisil (30/60 mesh)	GC/ECD	<0.5 μg Aroclor 1242/7.5g	2
Polyurethane foam plugs (2) + HiVol filter (1)	GC/ECD	<0.05 μg Aroclor 1242	11
Dichloromethane (DIG)	GC/MS	<10 μg/l Dibenzofuran/Dioxin	2
	TCO	<0.1 mg/l	2
	Gravimetry	<0.5 mg/l	2
XAD-2 resin	TCO	<10 mg/kg	2
	Gravimetry	<20 mg/kg	2
Cyclohexane (DIG)	GC/MS	<10 μg/l Dibenzofuran/Dioxin	2
8% Na_2CO_3(aq)	Ion Chromatography	<0.2 mg/l Cl^-	2

Another requirement of the quality control program was the analysis of a series of field-based blanks. A list of the samples taken and the analytical results is presented in Table 24.

Quality Control of Analytical Procedures

In accordance with the program text requirements, a variety of quality control measures were implemented during the analysis period. These included use of a series of spiked samples provided by the GCA Organic Laboratory Quality Control Coordinator. Each of the representative matrixes were spiked with a known quantity of Aroclor 1242 and submitted into the analytical scheme as a "blind" spiked sample. The spiking solution was prepared by the QC Coordinator from an RTP/EPA standard reference material. (Lot No. 8937, 100 percent Purity Received 5/27/80 from Quality Assurance Section, Analytical Chemistry Branch, U.S. EPA, HERL, ETD (MD-69), Research Triangle Park, North Carolina 27711).

TABLE 24. QUALITY CONTROL CRITERIA/FIELD-BIASED BLANKS

Matrix	Analysis procedure	Analytical results	Number of samples
PCB train[a] - florisil - impinger waters - hexane/acetone rinses	GC/ECD	<1.0 µg Aroclor 1242	4
Method 5 train[a] - filter	GC/MS	<0.5 µg Dibenzofuran-Dioxin	2
-XAD-2 resin	GC/MS	<0.85 µg Dibenzofuran-Dioxin	
-XAD-2 resin	TCO/Gravimetry	<10 mg/kg/<20 mg/kg	2
-distilled, deionized water	Ion Chromatography	<0.2 mg/l Cl^-	2
- 8% $Na_2CO_3(aq)$	Ion Chromatography	<0.2 mg/l Cl^-	2
Polyurethane foam plugs (2) + HiVol filter (1)	GC/ECD	<0.3 µg Aroclor 1242	2

[a] One complete train was assembled for each day of testing.

[b] Train components only.

TABLE 25. PCB QUALITY CONTROL - FLORISIL SPIKES

	Aroclor 1242 (µg)		
	Actual	Observed	% Recovery
A	13	15	112
B	13	12	89
C	13	None[a]	-
$\bar{X}$	13.0(13.4)	13.0(13.5)	100

[a] None - Sample extract soiled during analysis sequence and could not be recovered.

Florisil Spikes--

Each of the three aliquots of Florisil adsorbent were spiked prior to extraction with a specified quantity of Aroclor 1242. These were prepared as an indication of the measurements accuracy of PCBs adsorbed on Florisil. The results of these measurements are summarized in Table 25. The average results of these determinations indicate acceptable recoveries for Aroclor 1242 adsorbed on Florisil adsorbent.

Impinger Waters--

Quality control monitoring of PCBs collected in impinger waters consisted of the use of "blind" spiked water samples submitted during the appropriate analysis sequence. Each of three water samples were prepared by the Organic Laboratory Quality Control Coordinator and submitted for analysis. The results are recorded in Table 26.

TABLE 26. PCB/AQUEOUS MEDIA

	Aroclor 1242 (μg)		
	Actual (μg)	Observed (μg)	% Recovery
A	6.7	7.5	112
B	6.7	7.2	107
C	6.7	8.9	133
$\bar{X}$	6.7	7.9	117

The results above, while somewhat high, are consistent with acceptance criteria maintained for the analysis of PCBs in aqueous media.[11]

PCB-Train Spikes--

As designated in the program test plan, sampling trains were spiked in the field with a solution of deuterated tetrachlorobiphenyl in acetone to provide procedural recovery data. The deuterated isomer was supplied (97 percent d) by KOR Isotopes, Cambridge, Mass. The spike was applied prior to the start of each sample run to the first impinger. Stack samples were quantitated for d_6-tetrachlorobiphenyl isomer during the GC/MS analysis sequence for PCBs. The results of these analyses are summarized in Table 27.

As can be seen in Table 27, the recovery efficiency of deuterated tetrachlorobiphenyl was low. The cause of this low recovery was investigated by GCA personnel. Potential sources of this problem were the spiking procedure used in the field and/or the laboratory procedure used to analyze the sample. Discussions with field and laboratory personnel indicated that normal procedures were followed. However, due to the relative newness of this sampling and analysis procedures and the infrequency of its use, an inadvertent error may have occurred. This could not be substantiated.

An attempt was made by the laboratory personnel to isolate any analysis error. These investigations included determination of the extraction efficiency of the d_6-isomer from an aqueous sample under a number of pH conditions. These laboratory checks failed to pinpoint the source of the low recovery efficiency.

TABLE 27. PCB QUALITY CONTROL - TRAIN RECOVERY

Run No.	Test day	Air volume sampled (dscm)[a]	d_6-tetrachlorobiphenyl actual (μg)	Observed (μg)	% Recovery
PCB-1	1	4.898	11	2.0	18
-2	2	5.380	11	1.0	9.1
-3	3	5.785	11	4.7	43
-4	3	5.964	11	3.1	28
-5	4	3.207	11	N/A	-
				$\bar{X}$ =	25

[a] Dry standard cubic meters.

N/A - Sample lost during analytical sequence.

Polyurethane Foam Spikes--

Each of three sets of polyurethane foam plugs were prepared by the Organic Laboratory Quality Control Coordinator. These were submitted during the ambient portion of the analysis program as "blind" spiked samples. The results of these are summarized in Table 28.

TABLE 28. PCB QUALITY CONTROL - FOAM PLUG SPIKES

	Aroclor 1242 (μg)		
	Actual	Observed	% Recovery
A	6.7	6.0	90
B	6.7	6.2	93
C	6.7	6.2	93
$\bar{X}$	6.7	6.1	91

The average results of these measurements are consistent with recoveries of 96 percent reported by other investigation.[9]

Polyurethane Foam Plugs - Retention Efficiency Study--

Additional quality control measures included a collection efficiency test conducted at the GCA/Technology Division Laboratory in Bedford, Massachusetts. This test consisted of spiking a set of polyurethane foam plugs and Hi-Vol filter with a known amount of Aroclor 1242. This spike was applied directly to the filter in an assembled Hi-Vol apparatus. The spiking solvent was allowed to evaporate before startup of the apparatus. The sampler was operated at a flow rate of 26 ft^3/min for 3 hours. A blank sampler was operated simultaneously to provide background correction.

The samples were collected and analyzed for PCB according to previously described methods for ambient samples. The results are summarized in Table 29.

TABLE 29. PCB QUALITY CONTROL - FOAM PLUG RETENTION EFFICIENCY

	Volume of sampled air (dscm)[a]	Aroclor 1242 (μg)		
		Actual	Observed	% Recovery
Spike	131	5.0	5.0	100%
Blank	112	-	<0.5	-

[a] Dry standard cubic meters.

The results indicate sufficient retention of Aroclor 1242 on the foam plug matrix using a 26 ft^3/min flow rate and a 3-hour sampling time.

Fuel Oil Analysis--

In accordance with the program quality control protocol, a series of spiked fuel oil samples were also analyzed. Each of three 0.5 grams aliquots of No. 6 fuel oil were spiked with 25 μg of Aroclor 1242 (Applied Science) and analyzed per the procedure outlined earlier in the analytical method section of this report. The results of these analyses are summarized in Table 30.

TABLE 30. QUALITY CONTROL - PCBs/FUEL OIL

	Aroclor 1242 (μg)		
Sample	Actual (μg)	Observed (μg)	% Recovery
A	25	24	96
B	25	24	96
C	25	23	92
$\bar{X}$	25	24	96
S_x	-	0.58	-

The above data indicates acceptable results for the determinations of PCBs in a fuel oil matrix.

Data Quality

The quality of program data was maintained jointly by the GCA/Technology Division Quality Control Committee in conjunction with the program staff including the services of a Program Statistician, Mr. Ralph D'Agostino.

The details of the data validation sequence included the following: daily verification of all program measurements by appropriate staff members; e.g., laboratory notebook entries, periodic audits of program data by GCA QA Manager, periodic submission of quality control samples with subsequent data reports by the organic laboratory QC coordinator, and statistical validation of program test results prior to final report submission by the program statistician.

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APPENDIX A

ANALYTICAL EQUIPMENT OPERATING PARAMETERS

TABLE A-1. GC/MS INSTRUMENTAL PARAMETERS FOR PCB ANALYSIS

Parameter	Gas Chromatographic Conditions
Column:	6 ft X 2 mm (I.D.) Pyrex packed with 1% SP2250 on 80/100 mesh Supelcoport
Injection Temperature:	275°C
Temperature Program:	• isothermal for 4.0 min at 160°C • linear program from 160°-270° at 10°C/min • isothermal for 15 min
	Mass Spectrometer Conditions
Emission:	300 μa
Integration Time:	250 msec/amu
Election Energy:	70 E.V.
Operating Condition:	Selected Ion Monitor

TABLE A-2. GC/MS CHARACTERISTICS OF STANDARDS FOR PCB ANALYSIS

Compound[a]	Retention time[b] (min)	Parent ion (m/e)	Secondary ion (m/e)
Biphenyl	3.0	154.1	153.1
2-Monochlorobiphenyl	5.2	188.1	152.1
3,3'Dichlorobiphenyl	10.7	222.1	224.1
2,4,5 Trichlorobiphenyl	12.0	256.0	258.0
2,3,'5 Trichlorobiphenyl	12.4	256.0	258.0
2,3',4',5 Tetrachlorobiphenyl	16.4	292.0	290.0
2,2,'4,4',6,6- Hexachlorobiphenyl	16.5	359.9	361.9
2,2',4,5',5 Pentachlorobiphenyl	17.2	325.9	323.9
2,2',3,4,5,5',6-Heptachlorobiphenyl	22.3	395.8	393.9
Decachlorobiphenyl	28.7	497.7	499.7
d_{10}-Anthracene	11.7	188.2	
d_6-Tetrachlorobiphenyl	19.0	298.1	296.1

[a] - Detection Limit - 1.0 ng/µl

[b] - GC/MS Instrumental Parameters - Table A-1.

TABLE A-3. GC/ECD PARAMETERS FOR PCB ANALYSIS

Instrument:	Hewlett-Packard Model 5840A with a Ni63 electron capture detector and a Model 7671A automatic liquid sampler	
Column:	6 ft X 2mm (I.D.) 1.5% OV-17/1.95%	
	QF-1 on 100/120 mesh Chromosorb WHP	
Temperatures:	Column	175°C
	Injector	270°C
	Detector	300°C
Flow Rate:	50 cc/min argon methane	
Detection Limit:	0.1 ng/µl Aroclor 1242	

TABLE A-4. GC/ECD PARAMETERS FOR DCB ANALYSIS

Instrument:	Perkin-Elmer Model 3920 with a Ni^{63} electron capture detector.	
Integrator:	Hewlett-Packard Model 3380S	
Column:	6 ft x 2 mm(I.D.) 3% SE 30 on 100/120 mesh Gas Chrom Q	
Temperatures:	Column	- 240°C
	Injector	- 270°C
	Detector	- 300°C
Flow Rate:	50cc/min argon methane	
Retention Time:	3.5 min	
Detection Limit:	0.1ng per injection	

TABLE A-5. TOTAL CHROMATOGRAPHABLE ORGANICS (TCO) - OPERATING PARAMETERS

Parameter	Description
Instrument:	Tracor 560 gas chromatograph with dual FID
Recorder/Integrator:	Hewlett-Packard 3380S
Chart Speed:	1 cm/min
Column:	10 percent SP-2100 on Supelcoport 100/120 6 ft x 2 mm I.D. glass column
Carrier Gas:	20 ml/min prepurified N_2
Oven Temperature:	50°C for 5 min, programmed 50°-250°C at 10°/min, hold at 250°C for 2 min
Injector Temperature:	275°C
Detector Temperature:	300°C
Injection Volume:	2.0 µl

Table A-9 lists analyzer specifications for all flue gas monitoring equipment.

Oxygen concentrations were determined using a Beckman Model 741 Paramagnetic O_2 Analyzer with a measuring range of 0 to 10 percent O_2 full scale. The Analyzer was calibrated at 0 percent O_2 with ultrapure nitrogen and with 8.03 percent O_2 certified calibration gas before and after each test.

Carbon dioxide concentrations were determined using an Infrared Industries Model 702 NDIR Carbon Dioxide Analyzer with a measuring range of 0-30 percent CO_2 full scale. The Analyzer was calibrated at 0 percent CO_2 with ultrapure nitrogen and with 7.99 percent CO_2 certified calibration gas before and after each test period.

Carbon monoxide concentrations were determined using Beckman Model 65 NDIR CO Analyzer with a measuring range of 0-50 ppm CO full scale and was calibrated at 0 ppm CO with ultrapure nitrogen and with 39.9 ppm certified calibration gas before and after each test period.

Total hydrocarbon concentrations were determined using a Beckman Model 108-A Flame Ionization Hydrocarbon Analyzer with a measuring range of 0-50 ppm full scale. It was calibrated at 0 ppm with ultrapure nitrogen and with 40.1 ppm methane certified calibration gas before and after each test period.

Four strip chart recorders were used to record all monitoring data. The data were later corrected for calibration drift, if any, and reduced to 15-minute averages. Maximum and minimum values for each test burn period were also determined. These are based on a statistical treatment of actual measurements, not the 15-minute averages.

Other physical parameters were also measured in this testing program. These parameters included the flue gas velocity, static pressure and temperature. These measurements were made before each run to determine proper nozzle size and sampling rate. Additional physical parameters were measured during the course of each test. A complete list of all parameters monitored by GCA at the stack is included in Appendix A, Table A-7; and those monitored by GM is included in Appendix A, Table A-8.

COMBUSTION TEMPERATURE MONITORING

Instrumentation was installed on No. 3 boiler, for the verification-burn, to measure and record flame temperature and furnace gas temperature. Flame temperature was measured with an optical pyrometer mounted on the burner front of the boiler. Furance gas temperature was measured with a grounded junction thermocouple inserted through the rear wall of the boiler.

FLAME TEMPERATURE

Flame temperature was measured with a Modline "Q" Series Infrared Pyrometer, Type Q45F05, Serial 100796. This instrument has a range of 1500°F to 4500°F and incorporates analog readout. The unit was factory calibrated. Emissivity

TABLE A-9. ANALYZER SPECIFICATIONS OF CONTINUOUS MONITORS

	Infrared industries Model 702/703 CO_2 analyzer	Beckman Model 864 CO_2 analyzer	Beckman Model 108-A hydrocarbon analyzer	Beckman Model 865 CO analyzer	Beckman Model 741/742 O_2 analyzer
Operating sensitivity ranges	0-10% CO_2, FS 0-30% CO_2, FS	0-10% CO_2, FS 0-50% CO_2, FS 0-100% CO_2, FS	Adjustable from 1 ppm CH_4 full scale to 2% CH_4 Full scale	0-50 ppm CO, FS 0-100 ppm CO, FS 0-1000 ppm CO, FS	0-1% O_2, FS 0-5% O_2, FS 1-10% O_2, FS 0-25% O_2, FS
Operating temperature ranges	32°F - 120°F	32°F - 120°F	32°F - 110°F	30°F - 120°F	32°F - 110°F for sensor -20°F - 122°F for analyzer
Linearity	± 1% of full scale	± 1% FS		± 1% FS	± 1% of full scale
Accuracy	± 1% of full scale [a]	± 1% of full scale [a]	± 1% of full scale	± 1% of full scale [a]	± 1% of full scale
Stability (precision)	± 1% of full scale in 24 hours [a]	± 1% of full scale in 24 hours [a]	± 1% of full scale in 24 hours	± 1% of full scale in 24 hours [a]	± 0.25% of full scale at constant temperature ± 1% of full scale for temperature deviations of -20°F to 122°F

[a] Performance specifications based on ambient temperature shifts of less than 20 Fahrenheit degrees at a maximum rate of 20 Fahrenheit degrees per hour.

was set to "1.0" for the verification-burn. The pyrometer will be mounted to the burner front of the boiler in such a manner that line of sight access to the burner flame is realized.

Flame temperature was continuously recorded on an Esterline Angus Miniservo Strip Chart Recorder, Model MS401BB, Serial S-22243-1A. This recorder has a range of 0-100 mv. (0-100 percent). The unit was calibrated on March 26, 1980 by General Electric.

The optical pyrometer was installed to monitor the flame which exhibits the lower observed temperature (of the two burner flames). A normal operating temperature range was established for this burner using the optical pyrometer. Flame temperature was manually read and recorded once each 15 minutes during the verification-burn. Input of PCB contaminated oil to the boiler was to be stopped immediately if the observed flame temperature dropped 100°F or more below the established normal operating temperature.

FURNACE GAS TEMPERATURE

Furnace (fire box) gas temperature was measured with a grounded junction, Inconel sheath, Type "K" Megopack thermocouple (two foot length). The thermocouple was inserted through an observation port in the rear wall of the boiler. The thermocouple junction was approximately 1 foot from the inside face of the furnace rear wall.

Furnace gas temperature was continuously recorded on a Honeywell strip chart recorder, Model 143C10PS-24W7-2, Serial 552. The recorder has a range of 0-2400°F.

Furnace gas temperature was manually read and recorded once each 15 minutes during the verification-burn.

APPENDIX B

WORK PLAN FOR EVALUATION OF PCB DESTRUCTION EFFICIENCY OF NO. 3 INDUSTRIAL BOILER AT CHEVROLET-BAY CITY

April, 1980

Prepared by
A.P. Garwick, Jr.

Chevrolet - Bay City
Chevrolet Motor Division
General Motors Corporation

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INTRODUCTION

Objective

EPA has promulgated a final rule to implement provisions of the Toxic Substances Control Act prohibiting the manufacture, processing, distribution in commerce, and use of PCB's. Subpart B of 40 CFR Part 761 relates to disposal of PCB's. The final rule permits the disposal of liquid wastes with 50 to 500 ppm PCB in a case-by-case approval basis in high efficiency boilers.

In order to gather data relative to PCB destruction efficiency of industrial boilers, the United States Environmental Protection Agency and General Motors Corporation have developed a sampling and analysis protocol for a verification burn to evaluate the PCB destruction efficiency of the No. 3 industrial boiler at Chevrolet - Bay City in Bay City, Michigan.

Description Of The Verification Burn

The verification burn will require isokinetic sampling for PCB's in the combustion flue gas during three complete tests of the boiler at normal load operation and burning No. 6 fuel oil containing approximately 10 percent reclaim oil and 50 ppm PCB (500 ppm PCB in the reclaim oil). The No. 6 fuel oil/reclaim oil mixture will be fed to the boiler after normal burn temperature has been established. The sampling will require up to 6 hours for each run, based on an assumed destruction efficiency of 99.9 percent.

In order to provide background data on emissions from the boiler, a preliminary test will be conducted with No. 6 fuel oil only, one day prior to the initiation of the three day PCB verification burn. This test will be for the same duration and at the same conditions as those to be used for the PCB sampling. This test will provide background information on the test conditions and also provide emissions data for the boiler as operated at normal load and firing No. 6 fuel oil.

Description Of The Facility

Chevrolet - Bay City is a manufacturer of component parts for General Motors Corporation passenger cars and trucks. The manufacturing facility covers in excess of 1,000,000 square feet. Approximately 4,000 employes work at this location. In addition to the manufacturing and administrative facilities, the plant complex includes an industrial waste water treatment facility and a powerhouse (See Plot Plan, Figure 1).

The industrial waste water treatment facility is the source of the reclaim oil for the verification burn. The reclaim oil has been separated from the process waters collected within the manufacturing facility. The PCB's present in the reclaim oil are residuals which have persisted in purged hydraulic systems within the manufacturing facility. Prior to being burned in the No. 3 boiler, the reclaim oil will be processed through an on-site oil reclamation process to remove dirt and water. The reclamation process includes 20 micron diameter filtration

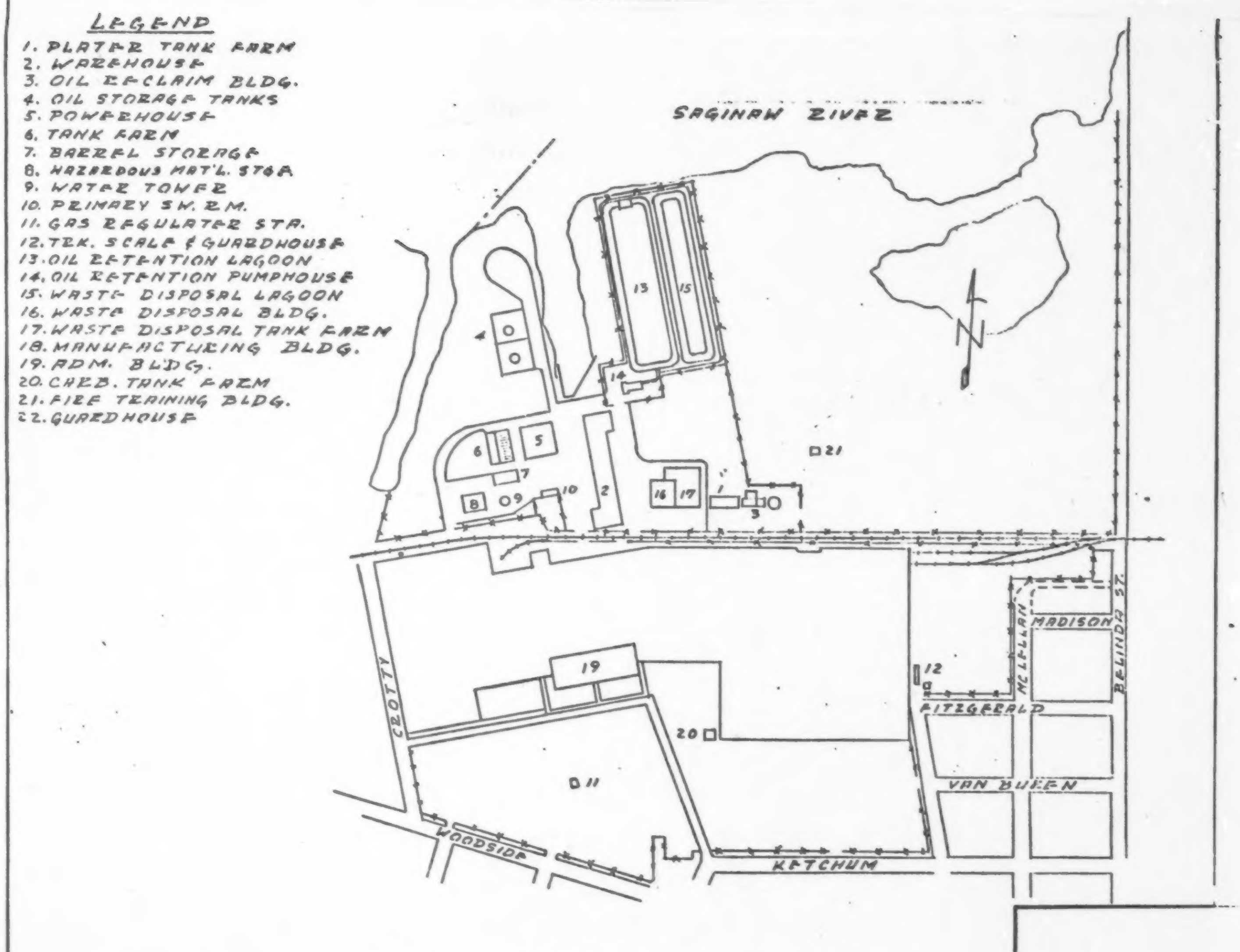
LEGEND
1. PLATER TANK FARM
2. WAREHOUSE
3. OIL RECLAIM BLDG.
4. OIL STORAGE TANKS
5. POWERHOUSE
6. TANK FARM
7. BARREL STORAGE
8. HAZARDOUS MAT'L. STGA
9. WATER TOWER
10. PRIMARY SW. RM.
11. GAS REGULATER STA.
12. TRK. SCALE & GUARDHOUSE
13. OIL RETENTION LAGOON
14. OIL RETENTION PUMPHOUSE
15. WASTE DISPOSAL LAGOON
16. WASTE DISPOSAL BLDG.
17. WASTE DISPOSAL TANK FARM
18. MANUFACTURING BLDG.
19. ADM. BLDG.
20. CHEM. TANK FARM
21. FIRE TRAINING BLDG.
22. GUARDHOUSE
SAGINAW RIVER
N
CROTTY
WOODSIDE
KETCHUM
VAN BUREN
FITZGERALD
MC LELLAN
MADISON
BELINDA ST.
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Figure 1. Chevrolet-Bay City Plot Plan.

followed by a centrifuge to remove water and more solids. The reclaim oil for the verification burn will contain less than 0.1% solids and less than 0.1% water.

The powerhouse at Chevrolet - Bay City provides steam, compressed air, and surface cooling water for the plant complex. Steam is generated in one or more of three oil-fired boilers. The steam requirement for the plant complex is dependent on heating load requirements. One or two boilers are required as the demand changes. A boiler normally remains in service for two months before being secured for inspection, cleaning, and repair. Each boiler is further inspected on an annual basis by the Michigan Department of Labor or its designated representative for license renewal.

The No. 3 boiler is a Wickes Type "A" 65-4K-7 package boiler installed in 1965, and having a steam generating capacity of 60,000 pounds per hour at 8 gallons per minute of No. 6 fuel oil. The No. 3 boiler is essentially identical to the other two boilers at this location except for the additional equipment added for the verification burn.

The boilers are normally fired on No. 6 fuel oil from two 200,000 gallon storage tanks. Each boiler may also be fired on No. 2 fuel oil from a 15,000 gallon back up system. The boilers are also equipped to burn natural gas, although no contractual supply is currently available.

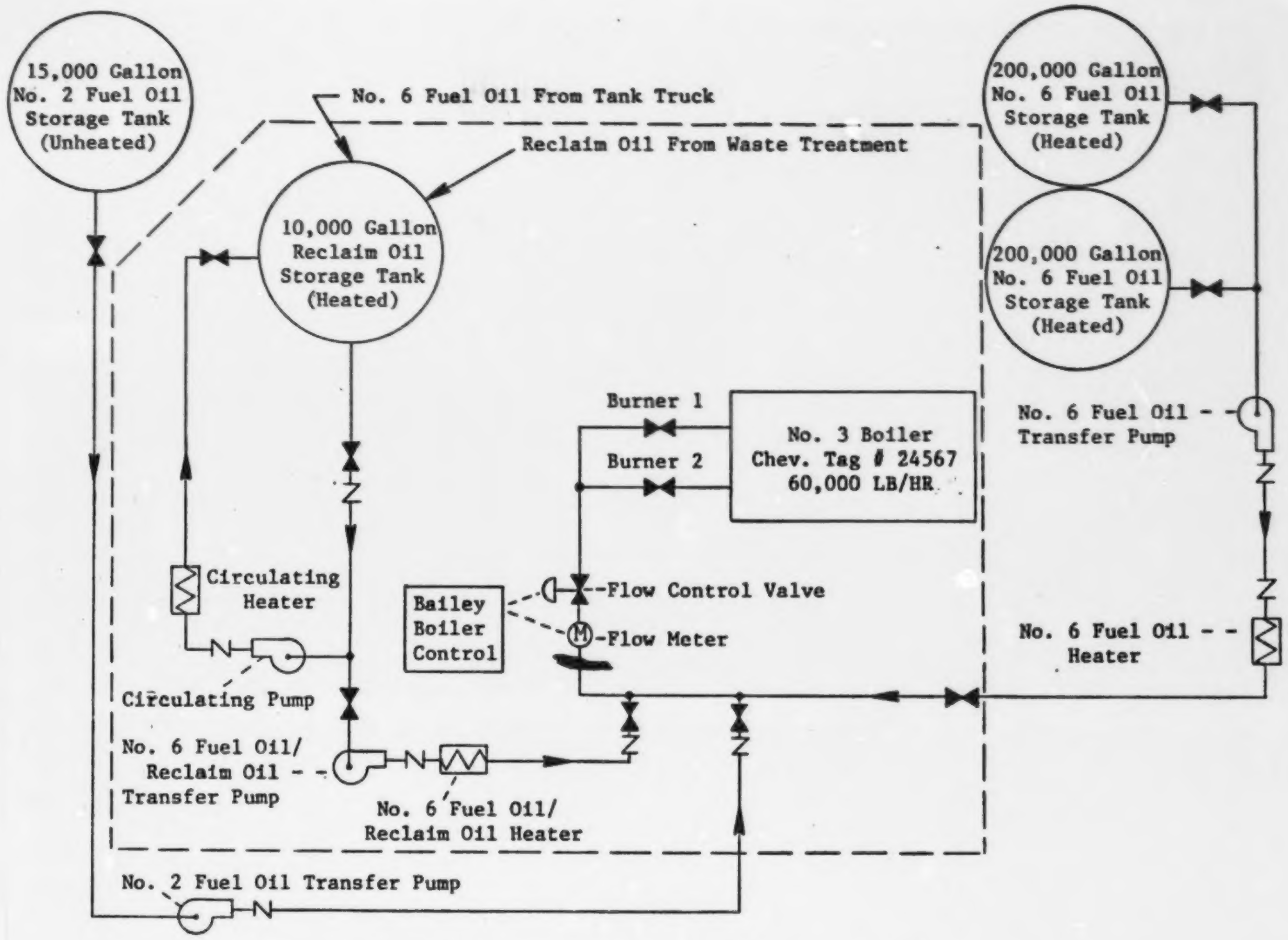
For the verification burn, No. 3 boiler will be fired on a mixture of approximately 90 percent No. 6 fuel oil and 10 percent reclaim oil from a 10,000 gallon reclaim oil tank at the powerhouse. The No. 6, No. 2, and reclaim oil systems are individually piped to the burner front of No. 3 boiler in a manner such that the fuel supply can be changed readily. (See Figure 2).

Work Plan Organization

The remainder of this work plan will describe the operating procedures, employe assignments, health protection, and PCB handling and containment procedures for the verification burn. This work plan complements GCA's "TEST PLAN FOR EVALUATION OF PCB DESTRUCTION EFFICIENCY IN INDUSTRIAL BOILERS" of March 1980.

The Operating Procedures section describes the organizational structure, day-by-day scheduling, instrumentation to be provided by Chevrolet, security provisions, and emergency provisions for the verification burn.

The Employe Health Effects Protocol section describes the medical examination procedures for determining general well-being of the powerhouse operators prior to the verification burn and to identify any possible health concerns associated


15,000 Gallon No. 2 Fuel Oil Storage Tank (Unheated)
No. 6 Fuel Oil From Tank Truck
Reclaim Oil From Waste Treatment
10,000 Gallon Reclaim Oil Storage Tank (Heated)
200,000 Gallon No. 6 Fuel Oil Storage Tank (Heated)
200,000 Gallon No. 6 Fuel Oil Storage Tank (Heated)
Burner 1
Burner 2
No. 3 Boiler Chev. Tag # 24567 60,000 LB/HR
No. 6 Fuel Oil Transfer Pump
Circulating Heater
Bailey Boiler Control
Flow Control Valve
Flow Meter
No. 6 Fuel Oil Heater
Circulating Pump
No. 6 Fuel Oil/ Reclaim Oil Transfer Pump
No. 6 Fuel Oil/ Reclaim Oil Heater
No. 2 Fuel Oil Transfer Pump

Reclaim Oil System Contained Within Dashed Lines

Figure 2. Fuel Oil Piping.

with previous burning of PCB contaminated oil.

The Workplace Monitoring section describes the employe breathing zone testing program and boiler residue analysis program which will be conducted in conjunction with the verification burn.

The PCB Related Activities section describes the handling, clean up, and disposal provisions for the verification burn.

OPERATING PROCEDURES

Organizational Structure

The verification burn will be conducted by General Motors Corporation, in close cooperation with the United States Environmental Protection Agency (EPA), the Michigan Department of Natural Resources (MDNR), and the GCA Corporation, EPA's contractor. General Motors will provide and operate the boiler, monitor and record boiler operating parameters, monitor the workplace, prevent and control spills, handle and dispose of wastes, and provide security. GCA will provide and operate the flue gas and ambient air sampling equipment, and perform the analytical work necessary to evaluate these samples. The organizational structure for the project is shown in Figure 3, Specific project assignments are as follows:

Plant Engineer (Chevrolet - Bay City (CBC)). The Plant Engineer has complete responsibility for and control of the verification burn. He will direct all aspects of the burn through the Chief Powerhouse Engineer and the Senior Environmental Engineer. The Plant Engineer will be the verification burn spokesman for Chevrolet - Bay City.

Chief Powerhouse Engineer (CBC). The Chief Powerhouse Engineer has responsibility for the safe operation of the boiler and associated equipment. He will direct the Powerhouse Operators, who will adjust and maintain the boiler and monitor boiler

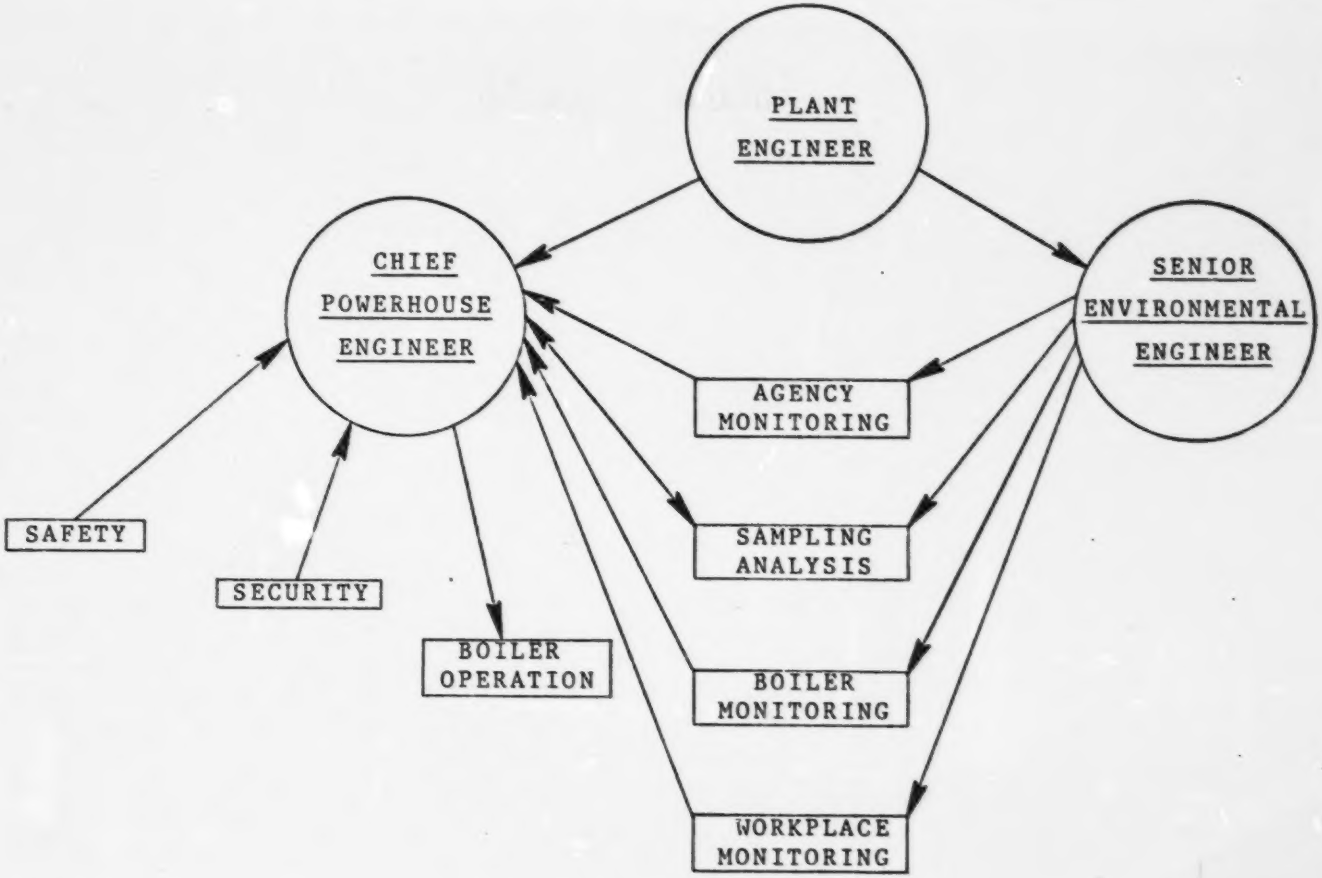

PLANT ENGINEER
CHIEF POWERHOUSE ENGINEER
SENIOR ENVIRONMENTAL ENGINEER
AGENCY MONITORING
SAMPLING ANALYSIS
BOILER MONITORING
WORKPLACE MONITORING
SAFETY
SECURITY
BOILER OPERATION

Figure 3. Organizational Structure.

operating parameters. The Chief Powerhouse Engineer will initiate, interrupt, and stop the verification burns, as required. All operational questions and comments will be directed to him.

Senior Environmental Engineer (CBC). The Senior Environmental Engineer has responsibility for all sampling, monitoring, and coordinating activities, other than safety and security. He will direct the General Motors monitoring activities and serve as the plant representative for the GCA sampling and analysis team. He will also be the plant representative for the EPA and MDNR.

Sampling Team Leader (GCA). The Sampling Team Leader has responsibility for all flue gas and ambient air sampling and analysis. He will be responsible to inform the Chief Powerhouse Engineer when the verification burn may begin, should be interrupted, and may be stopped, with respect to the sampling program. He will notify the Chief Powerhouse Engineer immediately if any monitored parameter exceeds its allowable range.

Monitoring Team Leader (CBC). The Monitoring Team Leader has responsibility for all boiler parameter monitoring and recording. He will notify the Chief Powerhouse Engineer immediately if any monitored parameter exceeds its allowable range. The Monitoring Team Leader will be assisted by a Powerhouse Boiler Operator who will observe all readings.

Powerhouse Boiler Operators. The Powerhouse Boiler Operators will perform their normal job assignments under the direction of the Chief Powerhouse Engineer. The Operator who is firing will adjust and maintain the boilers and monitor boiler operating parameters. He will start and stop flow of the reclaim oil to No. 3 boiler upon the command of the Chief Powerhouse Engineer. He will assist the Monitoring Team Leader by observing all readings that are logged, and will notify the Chief Powerhouse Engineer immediately if any monitored parameter exceeds its allowable range, or if any other operational problems arise. This Operator will be relieved and supplemented as required by other Powerhouse Boiler Operators.

Sampling Team (GCA). The GCA Sampling Team will operate the flue gas and ambient air sampling equipment and analyze samples, under the direction of the Sampling Team Leader, as described in the GCA "TEST PLAN FOR EVALUATION OF PCB DESTRUCTION EFFICIENCY IN INDUSTRIAL BOILERS" dated March 1980. The Sampling Team will notify the Sampling Team Leader immediately if any monitored parameter exceeds its allowable range. The Sampling Team will notify the Chief Powerhouse Engineer directly in the absence of the Sampling Team Leader.

Industrial Hygienist (GM). The Industrial Hygienist has responsibility for employe breathing zone sampling within the powerhouse. He will take breathing zone air samples before, during and after the burning of the PCB contaminated oil. He will be responsible for the analysis of the samples. The Industrial Hygienist will also observe the workplace during the verification burn and report any concerns to the Chief Powerhouse Engineer. The Industrial Hygienist will coordinate his activities through the Senior Environmental Engineer.

Governmental Agency Representatives (EPA, MDNR). Representatives of the United States Environmental Protection Agency and Michigan Department of Natural Resources will observe the verification burn and monitor procedures and activity as directed by their respective agency management. Agency Representatives will coordinate their activity through the Senior Environmental Engineer.

Scheduling

The verification burn will include equipment set-up and preparation, a five-hour background burn, three five-hour burns with PCB contaminated oil, clean-up, securing of the boiler, and removal of the test equipment. The entire verification burn will require approximately one week as detailed below, and in the GCA "TEST PLAN FOR EVALUATION OF PCB DESTRUCTION EFFICIENCY IN INDUSTRIAL BOILERS".

Day One Day One will begin with the arrival of the GCA Sampling Team and equipment. Chevrolet Plant Engineering Personnel will orient and assist the GCA Sampling Team by providing power and utility connections, laboratory and parking provisions, and security for equipment. Day One will precede the calendar week of the background and PCB contaminated oil burns.

Day Two The calendar week of the burns will begin with the background burn with No. 6 fuel oil, only, on Day Two. At approximately 7 A.M., the GCA Sampling Team will position and start the ambient air monitors and ready the flue gas monitoring equipment.

At approximately 9:30 A.M., the No. 3 boiler, which will already be at temperature and operating on No. 6 fuel oil, will be set to 4 gpm under manual control. The GCA Sampling Team Leader will notify the Chief Powerhouse Engineer when the flue gas monitoring equipment is ready. The Chief Powerhouse Engineer will verify that the boiler is stable and within allowable operating parameter limits. At approximately 10:00 A.M., the Chief Powerhouse Engineer will instruct the Sampling Team Leader and the Monitoring Team Leader to begin the test.

The test will continue for five hours, but possibly longer, until approximately 4:00 P.M. The Sampling Crew Leader will notify the Chief Powerhouse Engineer when the flue gas sampling is complete. Monitoring and recording will cease, except for the ambient air monitors and normal monitoring for the boiler. The boiler firing rate will be adjusted consistant with the steam demand from the plant complex. The special equipment will be secured for the day. At the completion of the ambient air monitoring for the day, the GCA Test Crew will secure those samplers.

Day Three. Day Three will proceed as did Day Two, except that the PCB contaminated oil will be substituted for No. 6 fuel oil. The substitution will be accomplished after the Sampling Crew Leader has indicated that the test may begin. The boiler will already have been stabilized on No. 6 fuel oil at 4 gpm. Upon the instruction of the Chief Powerhouse Engineer, the Powerhouse Boiler Operator will start the reclaim oil supply pump and verify system pressure. He will then open the manual stop valve in the reclaim supply line, and close the manual stop valve in the No. 6 fuel oil supply line. The reclaim oil flow rate and temperature will be adjusted as required. When the boiler is stable, the Chief Powerhouse Engineer will instruct the Sampling Team Leader and the Monitoring Team Leader to begin the test.

Upon completion of the test, at approximately 4:00 P.M., the boiler will be returned to operation on No. 6 fuel oil by reversing the valve and pump sequence above. The boiler firing rate will be adjusted as required, and the special equipment secured as in Day Two.

Day Four. Day Four will be a repeat of Day Three.

Day Five. Day Five will be a repeat of Day Three, until the completion of the sampling program. After the flow of reclaim oil to the boiler has been stopped and the boiler has been stabilized on No. 6 fuel oil, steam load will be shifted from No. 3 boiler and it will be secured and allowed to cool for inspection. The special equipment will be secured as in Day Two.

Day Six. The special equipment will be removed from the boiler during Day Six. Chevrolet personnel will open the boiler and sample residue from the interior of the firebox and from the hot side of the air preheater wheel. Protective clothing will be worn by the personnel collecting the samples. The boiler will be resealed until the results of the residue analysis are available.

Instrumentation Provided By Chevrolet

Existing controls, typical of this type of boiler, will be used to monitor and record the operation of No. 3 boiler during the verification burn. Additional instrumentation will be installed by GCA and Chevrolet for the verification burn only. The equipment provided by GCA is detailed in their "TEST PLAN FOR VERIFICATION OF PCB DESTRUCTION EFFICIENCY IN INDUSTRIAL BOILERS." The equipment provided by Chevrolet will measure and record flame and furnace gas temperature and oil flow rate as described below. Parameters monitored by Chevrolet will be manually read and recorded once each 15 minutes during the verification burn.

Existing Boiler Controls. The existing boiler controls which will be used to monitor the operation of the boiler during the verification burn are listed below:

Parameter Monitored	Instrument Range	Normal Parameter Range
Fuel oil temperature	50-300°F.	Ambient-200°F.
Fuel oil flow rate	0-8 gpm	1-8 gpm

Parameter Monitored	Instrument Range	Normal Parameter Range
Atomizing steam pressure	0-160 psig	15-110 psig
Steam flow rate	0-70 MLB/Hr.	10-70 MLB/Hr.
Smoke density (in stack)	1-100%	5-20%
Windbox pressure	0-10" w.c.	0.5-7.5"w.c.
Firebox pressure	0-10" w.c.	0-5.5"w.c.
For Air Preheater:		
Air temperature in	0-600°F.	Ambient
Air temperature out	0-600°F.	250-350°F.
Gas temperature in	0-600°F.	350-580°F.
Gas temperature out	0-600°F.	200-300°F.
Air pressure in	0-15" w.c.	0.5-10.5" w.c.
Air pressure out	0-15" w.c.	0.5- 8.0" w.c.

The existing boiler controls for No. 3 boiler were checked and calibrated by the Baily Meter Company on April 15, 1980. The opacity meter for measuring smoke density in the exhaust stack of No. 3 boiler will be cleaned and calibrated each night of the verification burn, after the day's test has been completed.

Flame Temperature will be measured with a Modline "Q" Series Infared Pyrometer, Type Q45F05, Serial 100796. This instrument has a range of 1,500°F. to 4,500°F and incorporates analog readout. The unit has been factory calibrated. Emissivity will be set to "1.0" for the verification burn. The pyrometer will be mounted to the burner front of the boiler in such a manner that line of sight access to the burner flame is realized.

Flame temperature will be continuously recorded on an Esterline Angus Miniserve Strip Chart Recorder, Model MS401BB, Serial S-22243-1A. This recorder has a range of 0-100 mv. (0-100%). The unit was calibrated on March 26, 1980 by General Electric.

The optical pyrometer will be installed to monitor the flame which exhibits the lower observed temperature (of the two burner flames). A normal operating temperature range will be established for this burner using the optical pyrometer. Flame temperature will be manually read and recorded once each 15 minutes during the verification burn. Input of PCB contaminated oil to the boiler will be stopped immediately if the observed flame temperature drops 100°F. or more below the established normal operating temperature.

Furnace Gas Temperature. Furnace (firebox) gas temperature will be measured with a grounded junction, Inconel sheath, Type "K" Megopack thermocouple (two foot length). The thermocouple will be inserted through an observation port in the rear wall of the boiler. The thermocouple junction will be approximately one foot from the inside face of the furnace rear wall.

Furnace gas temperature will be continuously recorded on a Honeywell strip chart recorder, Model 143C10PS-24W7-2, Serial 552. The recorder has a range of 0-2,400°F.

Furnace gas temperature will be manually read and recorded once each 15 minutes during the verification burn.

Reclaim Oil Flow Rate. Oil flow to the boiler will be measured and controlled by the existing boiler controls. The flow rate to the boiler during the verification burn will be maintained at 4 gpm. For the verification burn, oil flow to the boiler will also be measured and recorded by a Clampitron portable ultrasonic clamp-on flow meter, Series 240, Model 241MP-12-A-T, Serial 932CA. This instrument has a velocity range of 0 to 30 feet per second. The unit has been factory calibrated, and requires zero flow adjustment only prior to the verification burn. The unit provides instantaneous digital readout in gallons per minute and accumulates total gallons registered. This instrument will not be used to control oil flow to No. 3 boiler, but will be used only to collect additional data for the verification burn.

Security

The PCB contaminated reclaim oil is stored in tanks within diked areas on Chevrolet property. These areas are restricted to authorized personnel and are included in scheduled security patrols. Access to Chevrolet property is through secured entrances. Additional security requirements for the verification burn concern facilities for visitors and instrument protection.

Facilities For Visitors Visitors may gain access to the Chevrolet plant through the lobby of the administration building between the hours of 6:30 A.M. and 5:00 P.M., and through the west employe entrance at other times. Visitors should identify themselves and their business to the employe on duty and sign in. Each visitor will be issued safety glasses and an identification badge before entering the plant complex. Chevrolet personnel will escort visitors to and from the Powerhouse. Visitors requiring early entry or late exit should make prior arrangements through the Plant Engineering Department. Messages for visitors should also be directed through the Plant Engineering Department.

Instrument Protection Instruments for the verification burn will be located within the Powerhouse, on the roof of the Powerhouse, at three remote locations on Chevrolet property, and at one location in a residential area of Bay City.

The Powerhouse is a restricted area which is kept locked at all times. It is manned 24 hours per day by Powerhouse Boiler Operators, and is included in scheduled security patrol checks. Only authorized personnel will be admitted to the Powerhouse during the duration of the verification burn. The instruments within and on the roof of the Powerhouse will be included in the security protection of the Powerhouse.

The ambient air monitors which will be located at the remote locations on Chevrolet property will be within the secured area of the plant fence. Access to this area will be through secured entrances. These monitors will be left in the field each night of the test and will only be relocated as required by changes in weather conditions. Dependent on placement on the property, some or all of the three monitors may be within observation limits of Chevrolet's closed-circuit television surveillance. The monitors will also be included in the scheduled security patrol checks.

The single ambient air monitor which will be located off Chevrolet property will be truck mounted. This monitor will be located each morning of the test and will be returned to the plant each night, after completion of the sampling program. The off-site monitor will be attended by Chevrolet personnel at all times that it is off Chevrolet property.

Emergency Procedures

The Chief Powerhouse Engineer will have complete responsibility for the safe operation of the boiler and associated equipment during the verification burn. He will be assisted in carrying out his responsibility by the Powerhouse Boiler Operators, the GCA Sampling Team, the Chevrolet Monitoring Team, and the personnel and resources of Chevrolet - Bay City. The Chief Powerhouse Engineer will initiate, interrupt, and stop the verification burn, as required by the sampling program and safety consideration. Safety will be of the greatest concern at all times. Established Chevrolet procedures for fire prevention, spill prevention and control, personal injury, and natural disaster will remain in effect for the verification burn.

EMPLOYE HEALTH EFFECTS PROTOCOL

Chevrolet - Bay City burned about 100,000 gallons of waste oil containing low concentrations of PCB's in our boilers between 1974 and 1977, with estimated destruction efficiencies of 99.9%. Because of concern by plant Powerhouse Operators that they were possibly exposed to excess levels of PCB's during past years, comprehensive medical examinations and blood tests were conducted on these employes. Their concerns resolved themselves into two questions which could be paraphrased as:

1. "What damage, if any have I sustained?"
2. "What residual PCB is there in my body, and could it push me over a critical threshold if I absorb more?"

With the endorsement of the Divisional and Corporation Medical Directors and with extensive consultation with experts in many specialized fields the plant set out to answer these two questions as directly and completely as possible.

With each employe, the plant medical department went into a searching medical history, detailed physical examination, special testing with electrocardiograms and lung capacity tests. However, it ultimately came down to blood testing for the answers. The answer to "What damage, if any have

I sustained?" was none.

All of the operators showed normal results in the 28 analytic tests of the chemistry of the blood, blood cell examinations, general cellular well-being, and the Medical Director's special concern, liver function. The question: "What residual PCB is there in my body, and could it push me over a critical threshold if I absorb more?", requires some background information. PCB testing is done only in a limited number of laboratories in the United States. One of these is that of the State of Michigan Department of Health which has had extensive experience testing for both PCB and PBB. The Health Department was not only cooperative in its execution of test procedures but offered advice and the benefit of their accumulated experience. Another experienced laboratory is the Raltech Laboratory of Madison, Wisconsin which did the PBB testing for Dr. Selikoff when he surveyed the farm families involved in the Michigan PBB contamination incident.

Blood samples were split and sent, half of each, to these two laboratories both to check accuracy and assure back-up in case specimens met disaster in the mails. No such disaster occurred, and after consulting with the directors of each laboratory, good agreement was found in the test results. The widespread low level contamination of soil, water, fish, and wildfowl requires sampling of an average population for comparison (There is no normal amount of PCB in human blood). The State of Michigan had previously conducted testing in Michigan and was able to provide data from an average population group with no industrial exposure. Their reference group was divided in two parts on the basis of average weekly consumption of lake fish, (In excess of 8 oz. or less than 8 oz.). Michigan residents, whose daily intake of lake fish exceeds 8 oz. per week, ranged from 25 to 366 parts per billion. The range for Michigan residents who consume less than 8 oz. per week is 7 to 42 parts per billion. Powerhouse employes ranged from 7 to 36 parts per billion.

The average level for plant boiler operators was 18 parts per billion. For non-fish consuming Michigan residents it is 20 parts per billion. For those exceeding 8 oz. of Great Lakes area fish per week it is 73 parts per billion.

Each Powerhouse employe was given a copy of the results of all of his testing accompanied by reference normals where applicable. This tabulation was then reviewed in a personal summary with the Medical Director.

At this time, Chevrolet was able to provide the answer to question number two above:

The residual PCB in the blood streams of plant operators is equal to or lower than that of comparison groups throughout the state. Furthermore, the proposed test-burn is designed so that under "worst-case" conditions no significant additional burden of PCB would be introduced into the bodily systems of anyone.

WORKPLACE MONITORING

In order to determine the extent to which the Powerhouse Boiler Operators are exposed to PCB by burning the contaminated oil, the General Motors Industrial Hygiene Department will conduct employe breathing zone tests during the verification burn. Samples of the residue from within the boiler will also be taken and analyzed to determine the extent to which the Powerhouse Boiler Operators could be exposed to PCB during cleaning of the boiler.

Employe Breathing Zone Tests

Continuous samples will be taken from the breathing zone of each Powerhouse Boiler Operator during the entire time that PCB contaminated oil is being burned, and during the corresponding period of the background burn. In addition to the samplers on each Operator, four stationary samplers will also be located in the Powerhouse. Two of the stationary samplers will be located on the first floor of the Powerhouse in the immediate area of the burner front of No. 3 Boiler. The other two stationary units will be located on the third floor of the Powerhouse, in the immediate area of the exhaust duct expansion joint.

All the samplers will utilize solid absorbent tubes containing approximately 350 mg. each of Florisil. The Operator breathing zone samples will be drawn with SKC Model 222-3S Personal Sampling Pumps, operating at approximately 150 cc/min. Two 3 hour samples will be taken for each operator during each day (the samplers will be transferred to the Second Shift Operators at shift change). The PCB detection limit for the personal samples will be on the order of 50 ug/m^3 or less.

The two stationary locations will each include one SKC sampling pump operating as described above, and one MSA Model "G" Pump operating at approximately 350 cc/min. for approximately six hours. The six hour tests with the MSA pumps will provide a PCB detection limit on the order of 10 ug/m^3 or less. The sampling and analytical techniques which will be used for the employe breathing zone tests follow the recommendations of the NIOSH Manual of Analytical Methods, Method P & CAM-253 for PCB's in Air.

Boiler Residue Sampling

Samples of the residue from the interior of the boiler firebox and from the hot side of the air preheater wheel will be taken after the boiler has been secured, cooled, and opened. The samples will be analyzed by Chevrolet Laboratory in Detroit to determine the extent to which Powerhouse Boiler Operators could be exposed to PCB during cleaning of the boiler.

Disposable protective clothing and full-face, positive pressure, air supply masks will be worn by the personnel collecting the samples within the boiler. After the samples have been collected, the boiler will be resealed until the results of the analysis are reviewed. Based on the residue analysis results, appropriate protective clothing will be provided for the Powerhouse Boiler Operators who will clean the boiler.

PCB RELATED ACTIVITIES

Special handling and cleanup procedures will be used during the verification burn, due to the presence of the PCB contamination in the reclaim oil. The reclaim oil will have been spiked to near, but less than 500 ppm PCB and then will have been mixed with No. 6 fuel oil so that the reclaim oil accounts for 10 percent or less of the total mixture by volume. The concentration of the contaminated oil to the boiler will be approximately 50 ppm PCB. The oil will be considered to be at least 50 ppm PCB for safety and handling procedures.

Spill Prevention and Control

The prevention of spills of oil, fuel, and other hazardous materials is far superior to clean-up. Operation methods and procedures have been established to prevent the occurrence of polluting spills. However, accidental discharges could occur due to operator error or equipment failure while transferring, storing, distributing, or transporting these materials. These accidental discharges could enter the waterways directly as surface run-off or indirectly through either sanitary or storm sewer systems.

Chevrolet - Bay City has established procedures to prevent polluting discharges from storage, use, distribution, and bulk receiving areas and to provide procedures for prompt clean-up and containment of accidental discharges. These procedures are contained within the Chevrolet - Bay City Spill Prevention Control and Countermeasure Plan (SPCC)/ Pollution Incident Prevention Plan (PIPP), which was last reviewed and revised on November 10, 1979. Copies of the SPCC/PIPP are on file in the Powerhouse, Plant Engineering Department, Maintenance Department, Metallurgical Laboratory, and at Plant Security Headquarters.

Waste Handling and Disposal

PCB contaminated materials will be collected and deposited in sealable 55 gallon containers which will be located in the Powerhouse Near No. 3 boiler. Contaminated materials will include oil drippings, absorbents, rags, gloves, disposable clothing, boiler residue, etc. The containers will be identified as containing PCB, and will be serialized and logged. Full containers will be sealed,checked, and transported directly to the secured PCB storage area to await proper disposal. All PCB materials will be disposed of in accordance with the applicable provisions of the law.

Employe Training

The Powerhouse Boiler Operators at Chevrolet - Bay City are all licensed by the City of Saginaw, Michigan. Each is experienced with the operation of the Powerhouse, and is thoroughly familiar with the operation of No. 3 boiler and its associated equipment.

Prior to the week of the verification burn, training burns will be conducted using the reclaim oil system and No. 6 fuel oil only. These practice sessions will allow the Operators to familiarize themselves with the operation of the reclaim oil system, and with the procedure for switching No. 3 boiler from No. 6 fuel oil to reclaim oil and back to No. 6 fuel oil.

Also prior to the week of the verification burn, this work plan will be reviewed with each Operator who will be directly involved with the verification burn. Each Operator will also receive his own personal copy of the Work Plan for ready reference.

APPENDIX C

PROCEDURE FOR PCB AIR SAMPLE ANALYSIS

1. Transfer the Florisil into a 10 ml volume flask.
2. Pipette 4 ml of n-hexane (Pesticide Grade) into the volume glask. Wait for at least 10 minutes.
3. Run the final solution on Gas Chromatography with Electron Capture Detector.
4. Compare the fingerprints with known Aroclor to determine what kind of PCB is in the sample.
5. Determine the concentration of the PCB in samples by comparing the average peak height of the sample and the liquid standards.

APPENDIX D

METHOD OF TESTING FOR POLYCHLORINATED BIPHENYLS (PCBs) IN BULK MATERIAL (SOLID)

1. The bulk sample is ground with a porcelain mortar and pestle to uniform particle size.

2. The sample is then put in a vacuum desiccator overnight. Prior to extraction, the sample is kept in a regular desiccator.

3. The weighed sample (5 - 10 g) is added to the thimble and a wad of glass wool is placed on the top. The extraction is then carried out in a soxhlet extractor using 150 ml n-Hexane for 4 hours.

4. The extract is then transferred to a beaker and concentrated to 1 - 2 ml in a heated vacuum (temperature set at 5) desiccator.

5. Rinse the beaker with n-Hexane and transfer the liquid through a Florisil tube (a disposable pipette packed with 2-1/2 inches of Florisil) to a 10 ml volume flask. The final solution is 10 ml.

6. Analyze the final solution by gas chromatography with electron capture detector to determine the concentration of PCBs. Inject 5 μl with a 1 μl back-up.

GC Condition:

Column: SE30 glass column 1/4 in. x 6 ft. Temp.: 200°

Detector temperature: Electron capture detector 300°

Injector temperature: 280°

Standard current: 0.5

7/7/80

APPENDIX E

PROCEDURES USED BY CHEVROLET CENTRAL OFFICE AND CHEVROLET BAY CITY LABORATORIES TO ANALYZE THE PCB WASTE OIL

Chevrolet Central Office Laboratory

Aroclor 1242 and 1254 were analyzed with gas chromatography using the procedure outlined on page 7 of the April 1980 EPA Newsletter (Volume 3, Number 2).

Metal analysis for arsenic, cyanide, mercury, nickel, selenium, and zinc used the methods from the EPA document titled "Test Methods for Evaluating Solid Waste," SW-846, May 1980.

Phenols were analyzed using the August 1977 EPA document titled "Interim Methods for the Sampling and Analysis of Priority Pollutants in Sediments and Fish Tissue."

Chevrolet Bay City Laboratory

Fire point was done by ASTM Method D-92. Sediment was done by ASTM Method D-96. Water was done by ASTM Method D-95. Viscosity was done by ASTM Method D-88.

APPENDIX F

GM BOILER OPERATION MEASUREMENTS

Boiler Operating Parameters - Background Run On May 5, 1980

Time	Fuel Oil Pressure (PSIG)	Fuel Oil Flow Rate (GPM)	Steam Flow Rate (MLB/HR)	Air Heater Temperature Air In (°F)	Air Heater Temperature Air Out (°F)	Air Heater Temperature Gas In (°F)	Air Heater Temperature Gas Out (°F)
Acceptable Range	15/ 120	3.9 4.1	10/ 70	Ambient	250/ 350	350/ 580	200/ 300
1510	38	4.0	40	80	355	475	N.O.
1525	38	4.0	40	80	355	475	N.O.
1540	38	4.0	40	80	355	475	N.O.
1555	38	4.0	41	80	352	474	N.O.
1610	38	4.0	41	80	352	472	N.O.
1625	38	4.0	40	80	351	471	N.O.
1640	38	4.0	40	80	352	472	N.O.
1655	39	4.0	39	80	352	473	N.O.
1710	40	4.0	38.5	80	353	476	N.O.
1725	39	4.0	39	80	353	477	N.O.
1740	39	4.0	38.5	80	353	478	N.O.
1755	40	4.0	38.5	80	358	480	N.O.
1810	40	4.0	38.5	80	358	460	N.O.
1825	40	4.0	38	80	358	480	N.O.
1840	40	4.0	38	80	359	480	N.O.
1855	40	4.0	38	80	358	481	N.O.
1910	40	4.0	38	79	356	481	N.O.
1925	40	4.0	38	76	356	482	N.O.
1940	40	4.0	38	74	355	483	N.O.
1955	39	4.0	38	72	355	483	N.O.
2010	39	4.0	38	71	356	483	N.O.
2025	39	4.0	38	71	355	482	N.O.
Average	39	4.0	39	78	355	478	N.O.
Range	2	0	3	9	8	12	N.O.
Std. Dev.	0.87	0	1.0	3.2	2.38	3.99	N.O.

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Boiler Operating Parameters - Background Run On May 5, 1980

Time	Windbox Pressure (in. w.c.)	Furnace Pressure (in. w.c.)	Flue Gas Opacity (%)	Fuel Oil Temperature (^oF)	Atomized Steam Press. (PSIG)	Air Heater Pressure In (in. w.c.)	Air Heater Pressure Out (in. w.c.)
Acceptable Range	0.5/ 7.5	0.5/ 5.5	5 or less	160/ 220	15/ 110	0.5/ 10.5	0.5/ 8.0
1510	4.5	3.0	2.5	191	48	6.0	5.0
1525	4.5	3.0	2.5	190	48	6.0	5.0
1540	4.25	3.25	2.5	191	48	6.0	5.0
1555	4.0	3.0	2.5	194	46	6.25	4.5
1610	4.5	3.5	2.5	196	48	6.25	4.75
1625	4.0	3.0	2.5	195	48	6.0	5.0
1640	4.0	3.0	2.5	190	48	6.25	4.5
1655	4.0	3.0	2.5	192	50	6.0	5.0
1710	4.5	3.5	2.5	194	50	6.0	5.0
1725	4.0	3.0	2.5	191	50	6.0	4.5
1740	4.5	3.25	2.5	192	50	6.0	5.0
1755	4.5	3.5	2.5	192	50	6.25	4.75
1810	4.25	3.0	2	190	50	6.25	5.0
1825	4.0	3.0	2	191	50	6.25	4.75
1840	4.5	3.25	2.5	191	50	6.25	4.75
1855	4.25	3.0	2	191	50	6.25	5.0
1910	4.5	3.25	2.5	190	50	6.25	4.75
1925	4.25	3.25	2	191	50	6.25	4.75
1940	4.25	3.25	2	192	51	6.5	5.0
1955	4.5	3.5	3	192	50	6.5	4.75
2010	4.25	3.25	3.5	192	50	6.5	5.0
2025	4.5	3.5	3	192	50	6.5	4.75
Average	4.3	3.2	2	192	49	6.2	4.8
Range	0.5	0.5	1.5	6	5	0.5	0.5
Std. Dev.	0.21	0.20	0.4	1.62	1.2	0.18	0.18

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TYPING GUIDE SHEET
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Boiler Operating Parameters - Background Run On May 5, 1980

Time	Steam Drum Water Level (Inches)	Flame Temperature (°F)	Back Wall Temperature (°F)	Oil Flow-Ultrasonic (GPM)	Wind Speed (MPH)	Wind Direction (Comp. Pt.)
Acceptable Range	5" of center			(Ref.)		
1510	+0.5	2625	1680	N.O.	20	W
1525	1.0	2650	1680	N.O.	15	W
1540	1.0	2625	1670	N.O.	25	W
1555	1.0	2600	1670	N.O.	25	W
1610	1.0	2625	1675	N.O.	20	W
1625	1.0	2625	1675	N.O.	26	WNW
1640	1.0	2625	1680	N.O.	20	W
1655	1.0	2650	1675	N.O.	18	W
1710	1.0	2650	1675	N.O.	20	W
1725	1.0	2625	1690	N.O.	19	W
1740	1.0	2650	1680	N.O.	19	W
1755	1.0	2650	1695	N.O.	20	W
1810	1.0	2650	1690	N.O.	19	W
1825	1.25	2650	1685	N.O.	19	W
1840	1.25	2625	1695	N.O.	18	WNW
1855	1.0	2625	1695	N.O.	15	N
1910	1.0	2640	1705	N.O.	23	NNW
1925	1.0	2625	1695	N.O.	20	N
1940	1.0	2625	1705	N.O.	20	N
1955	1.0	2640	1700	N.O.	15	N
2010	1.0	2600	1700	N.O.	10	N
2025	1.0	2625	1700	N.O.	12	N
Average	+1.0	2630	1690	N.O.	19	WNW
Range	0.75	50	35	N.O.	16	90°
Std. Dev.	0.13	15.4	11.5	N.O.	3.9	40°

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PAGE NUMBER

Boiler Operating Parameters - First PCB Run On May 8, 1980

Time	Fuel Oil Pressure (PSIG)	Fuel Oil Flow Rate (GPM)	Steam Flow Rate (MLB/HR)	Air Heater Temperature Air In (^{o}F)	Air Heater Temperature Air Out(^{o}F)	Air Heater Temperature Gas In (^{o}F)	Air Heater Temperature Gas Out (^{o}F)
Acceptable Range	15/ 120	3.9 4.1	10/ 70	Ambient	250/ 350	350/ 580	200/ 300
1400	38	4.0	39	68	352	508	N.O.
1415	38	4.0	39.5	70	356	506	N.O.
1430	38	4.0	38	69	358	508	N.O.
1445	38	4.0	37.5	69	358	509	N.O.
1500	38	4.0	39.5	69	358	505	N.O.
1515	38	4.0	41	68	355	505	N.O.
1530	38	3.9	41.5	66	352	502	N.O.
1545	38	4.0	43	67	352	500	N.O.
1600	36	3.9	40.5	67	350	495	N.O.
1615	36	4.0	40	67	350	500	N.O.
1630	36	4.0	40	68	352	506	N.O.
1645	35	3.9	43	67	352	506	N.O.
1700	36	4.0	40	65	355	510	N.O.
1715	36	4.0	41.5	65	354	508	N.O.
1730	36	4.0	43	65	354	505	N.O.
1745	36	4.0	41	65	350	502	N.O.
1800	36	4.0	39	65	353	510	N.O.
1815	36	4.0	38	65	355	510	N.O.
1830	38	4.0	39	65	359	515	N.O.
1845	38	4.0	39.5	65	359	512	N.O.
1900	38	4.0	41	65	358	510	N.O.
1915	38	3.9	40	65	350	505	N.O.
1930	36	4.0	38	65	352	505	N.O.
1945	36	4.0	38	65	350	502	N.O.
Average	37	4.0	40	66	354	506	N.O.
Range	3	0.1	5.5	5	9	20	N.O.
Std. Dev.	1.1	0.04	1.6	1.7	3.13	4.41	N.O.

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Boiler Operating Parameters - First PCB Run On May 8, 1980

Time	Windbox Pressure (in. w.c.)	Furnace Pressure (in. w.c.)	Flue Gas Opacity (%)	Fuel Oil Temperature (^{o}F)	Atomized Steam Press.(PSIG)	Air Heater Pressure In (in. w.c.)	Air Heater Pressure Out (in. w.c.)
Acceptable Range	0.5/ 7.5	0.5/ 5.5	5 or less	160/ 220	15/ 110	0.5/ 10.5	0.5/ 8.0
1400	5.5	4.0	0	203	48	7.5	6.0
1415	5.5	4.25	0	206	48	7.5	6.0
1430	5.5	4.25	0	206	48	7.5	5.5
1445	5.5	4.25	0	206	48	7.5	6.0
1500	5.0	3.75	0	204	48	7.5	6.0
1515	6.0	4.5	0	202	46	8.0	6.5
1530	5.5	4.0	0	200	45	8.0	6.0
1545	6.0	4.5	0	200	43	8.0	6.0
1600	5.5	4.0	0	198	44	8.5	6.0
1615	6.0	4.5	0	200	45	8.5	6.5
1630	5.75	4.5	0	201	45	8.5	6.0
1645	5.5	4.0	0	202	45	8.5	6.0
1700	6.0	4.75	0	202	46	8.5	6.0
1715	5.5	4.25	0	200	45	8.5	6.5
1730	5.5	4.0	0	199	45	8.5	6.0
1745	6.0	4.5	0	198	45	8.5	6.0
1800	6.0	4.5	0	202	46	8.5	6.5
1815	6.0	4.5	0	203	48	8.5	6.5
1830	6.0	4.5	0	204	47	8.5	6.0
1845	5.5	4.5	0	202	48	8.5	6.5
1900	5.5	4.0	0	201	46	8.5	6.5
1915	6.0	4.75	0	201	45	8.5	6.5
1930	5.5	4.0	0	199	45	8.5	6.0
1945	5.5	4.0	0	198	45	8.5	6.0
Average	5.7	4.3	0	202	46	8.2	6.1
Range	1.0	1.0	0	8	5	1.0	1.0
Std. Dev.	0.28	0.28	0	2.45	1.5	0.42	0.28

Page 2 of 3

Boiler Operating Parameters - First PCB Run On May 8, 1980

Time	Steam Drum Water Level (Inches)	Flame Temperature (^{o}F)	Back Wall Temperature (^{o}F)	Oil Flow-Ultrasonic (GPM)	Wind Speed (MPH)	Wind Direction (Comp. Pt.)
Acceptable Range	5" of center			(Ref.)		
1400	+0.75	2625	1690	5.10	10	NW
1415	1.0	2625	1675	4.20	10	NW
1430	1.0	2625	1680	3.90	13	NW
1445	1.0	2650	1675	3.50	13	NNW
1500	1.0	2650	1670	2.80	16	NNW
1515	1.0	2625	1650	N.O.	13	NW
1530	1.0	2625	1670	N.O.	20	NW
1545	1.0	2600	1655	N.O.	16	NNW
1600	1.0	2600	1660	N.O.	13	NW
1615	1.0	2600	1655	N.O.	13	NW
1630	1.0	2575	1660	N.O.	10	NW
1645	1.0	2575	1655	N.O.	13	WNW
1700	1.0	2625	1650	N.O.	15	WNW
1715	1.0	2575	1660	N.O.	10	WNW
1730	1.0	2575	1660	N.O.	12	NW
1745	1.0	2575	1660	N.O.	10	W
1800	1.0	2575	1645	N.O.	15	WNW
1815	1.0	2575	1650	N.O.	12	NW
1830	1.0	2600	1655	N.O.	19	WNW
1845	1.0	2600	1660	N.O.	15	NW
1900	1.0	2600	1645	N.O.	10	NW
1915	1.0	2600	1645	N.O.	5	NW
1930	1.0	2600	1660	N.O.	10	NW
1945	1.0	2575	1660	N.O.	15	NW
Average	+1.0	2600	1660	3.90	13	NW
Range	0.25	75	45	2.30	15	70
Std. Dev.	0.051	24.4	11.5	0.852	3.3	20

Page 3 of 3

Boiler Operating Parameters - Second PCB Run on May 9, 1980

Time	Fuel Oil Pressure (PSIG)	Fuel Oil Flow Rate (GPM)	Steam Flow Rate (MLB/HR)	Air Heater Temperature Air In (°F)	Air Heater Temperature Air Out (°F)	Air Heater Temperature Gas In (°F)	Air Heater Temperature Gas Out (°F)
Acceptable Range	15/ 120	3.9 4.1	10/ 70	Ambient	250/ 350	350/ 580	200/ 300
1300	38	4.0	39	68	362	525	N.O.
1315	38	3.9	39	65	361	512	N.O.
1330	38	4.0	39	65	361	523	N.O.
1345	38	4.0	39	65	361	525	N.O.
1400	38	4.0	38.5	65	361	522	N.O.
1415	38	4.05	38	64	361	522	N.O.
1430	38	4.0	37	64	361	523	N.O.
1445	38	4.0	39	64	361	523	N.O.
1500	38	4.0	40	65	360	520	N.O.
1515	38	4.0	40	65	360	510	N.O.
1530	36	3.9	36.5	65	360	515	N.O.
1545	43	4.05	37	65	365	530	N.O.
1600	42	4.0	35.5	65	366	530	N.O.
1615	42	4.05	37	65	370	530	N.O.
1630	42	4.1	38	65	365	530	N.O.
1645	40	4.1	39.5	65	365	525	N.O.
1700	38	4.05	39	65	360	521	N.O.
1715	40	4.0	39	65	360	520	N.O.
1730	38	4.1	40	66	360	520	N.O.
1745	38	4.0	40	65	360	520	N.O.
1800	38	4.05	40	65	360	520	N.O.
1815	38	4.1	40	65	360	520	N.O.
Average	39	4.0	39	65	362	522	N.O.
Range	7	0.2	4.5	4	10	20	N.O.
Std. Dev.	1.8	0.055	1.3	0.79	2.67	5.36	N.O.

Boiler Operating Parameters - Second PCB Run On May 9, 1980

Time	Windbox Pressure (in. w.c.)	Furnace Pressure (in. w.c.)	Flue Gas Opacity (%)	Fuel Oil Temperature (^{o}F)	Atomized Steam Press. (PSIG)	Air Heater Pressure In (in. w.c.)	Air Heater Pressure Out (in. w.c.)
Acceptable Range	0.5/ 7.5	0.5/ 5.5	5 or less	160/ 220	15/ 110	0.5/ 10.5	0.5/ 8.0
1300	6.0	4.5	1	205	50	8.5	6.5
1315	6.0	4.5	0	190	50	9.0	6.5
1330	6.0	4.5	1	192	50	8.5	7.0
1345	6.25	5.0	1	195	50	8.5	7.0
1400	6.5	5.0	1	195	50	9.0	6.5
1415	6.0	4.5	1	196	50	8.5	6.5
1430	6.0	4.5	1	196	50	9.0	6.5
1445	6.0	4.5	1	196	50	9.0	6.5
1500	6.0	4.5	1	194	50	8.5	6.5
1515	6.0	4.5	0	193	50	9.0	6.5
1530	6.0	4.5	0	195	45	9.0	6.5
1545	6.5	5.0	0	194	50	9.0	7.0
1600	6.0	4.5	0	193	52	9.0	7.0
1615	6.0	4.5	0	194	52	9.0	6.5
1630	6.0	4.5	0	193	50	9.0	6.5
1645	6.0	5.0	0	192	50	9.0	6.5
1700	6.5	5.0	0	192	50	9.0	6.5
1715	6.0	4.5	0	192	50	9.0	6.5
1730	6.0	4.5	0	191	50	9.0	6.5
1745	6.0	5.0	0	192	50	9.0	6.0
1800	6.0	4.5	0	192	50	9.0	6.5
1815	6.5	5.0	0	192	50	9.0	7.0
Average	6.1	4.7	0.4	194	50	8.9	6.6
Range	0.5	0.5	1	15	7	0.5	1.0
Std. Dev.	0.20	0.24	0.5	3.02	1.3	0.21	0.25

Page 2 of 3

Boiler Operating Parameters - Second PCB Run On May 9, 1980

Time	Steam Drum Water Level (Inches)	Flame Temperature (°F)	Back Wall Temperature (°F)	Oil Flow-Ultrasonic (GPM)	Wind Speed (MPH)	Wind Direction (Comp. Pt.)
Acceptable Range	5" of center			(Ref.)		
1300	+1.0	2600	1670	4.40	10	W
1315	1.0	2575	1675	3.70	12	NW
1330	1.0	2600	1690	3.60	12	W
1345	1.0	2575	1670	3.30	10	W
1400	1.0	2600	1675	3.00	12	W
1415	1.0	2600	1660	2.80	15	W
1430	1.0	2575	1650	2.60	12	WSW
1445	1.0	2550	1650	2.50	15	SW
1500	1.0	2550	1660	2.40	13	SW
1515	1.0	2550	1660	2.20	12	W
1530	1.0	2550	1570	1.80	10	W
1545	1.0	2575	1670	2.20	10	SW
1600	1.0	2575	1650	1.90	12	W
1615	1.0	2575	1660	1.75	15	W
1630	1.0	2600	1660	1.88	10	W
1645	1.0	2600	1660	1.50	15	W
1700	1.0	2575	1650	1.44	12	W
1715	1.0	2575	1650	1.65	10	W
1730	1.0	2550	1660	1.51	8	W
1745	1.0	2600	1650	1.42	12	W
1800	1.0	2575	1660	1.36	12	W
1815	1.0	2600	1670	1.18	10	W
Average	+1.0	2580	1660	2.28	12	W
Range	0	50	120	3.22	7	90°
Std. Dev.	0	19.4	22.2	0.878	2.0	20°

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Boiler Operating Parameters - Third PCB Run on May 10, 1980

Time	Fuel Oil Pressure (PSIG)	Fuel Oil Flow Rate (GPM)	Steam Flow Rate (MLB/HR)	Air Heater Temperature Air In (^oF)	Air Heater Temperature Air Out (^oF)	Air Heater Temperature Gas In (^oF)	Air Heater Temperature Gas Out (^oF)
Acceptable Range	15/ 120	3.9 4.1	10/ 70	Ambient	250/ 350	350/ 580	200/ 300
1400	40	4.0	38	57	362	530	N.O.
1415	36	4.3	34	60	350	510	N.O.
1430	32	4.3	35	60	340	470	N.O.
1445	30	4.2	36	60	330	452	N.O.
1500	30	4.2	36	60	320	445	N.O.
1515	30	4.1	34	60	320	440	N.O.
1530	30	4.1	32	60	320	445	N.O.
1545	30	4.1	31	60	321	450	N.O.
1600	30	4.1	31	60	325	445	N.O.
1615	30	4.0	30	60	335	450	N.O.
1630	30	4.1	30	65	325	440	N.O.
1645	30	4.2	29	65	322	435	N.O.
1700	30	4.0	28	65	320	430	N.O.
1715	30	4.1	28	65	320	425	N.O.
1730	30	4.1	28	65	318	422	N.O.
Average	31	4.1	32	61	329	453	N.O.
Range	10	0.3	10	8	44	108	N.O.
Std. Dev.	2.9	0.96	3.3	2.7	13.0	30.0	N.O.

Boiler Operating Parameters - Third PCB Run On May 10, 1980

Time	Windbox Pressure (in. w.c.)	Furnace Pressure (in. w.c.)	Flue Gas Opacity (%)	Fuel Oil Temperature (°F)	Atomized Steam Press.(PSIG)	Air Heater Pressure In (in. w.c.)	Air Heater Pressure Out (in. w.c.)
Acceptable Range	0.5/ 7.5	0.5/ 5.5	5 or less	160/ 220	15/ 110	0.5/ 10.5	0.5/ 8.0
1400	6.0	5.0	2	200	50	9.0	6.0
1415	6.0	5.0	2	200	42	8.5	6.5
1430	4.5	3.0	2	197	38	6.5	5.0
1445	4.0	3.0	2	195	38	6.0	4.5
1500	4.0	2.8	2	193	36	6.0	5.0
1515	4.0	3.0	2	194	37	6.0	4.0
1530	4.0	3.0	2	197	38	6.0	4.5
1545	5.0	3.0	2	199	38	6.0	4.5
1600	4.0	3.0	2	200	40	5.5	4.5
1615	4.0	3.0	2	201	38	5.5	4.0
1630	4.5	2.5	2	202	38	5.0	4.0
1645	3.0	2.0	2	204	38	4.5	3.5
1700	3.0	2.0	2	205	38	5.0	3.0
1715	3.0	2.0	2	205	38	4.5	3.0
1730	3.0	2.0	2	204	38	4.5	3.0
Average	4.1	3.0	2	200	39	5.9	4.3
Range	3.0	3.0	0	12	14	4.5	3.5
Std. Dev.	0.97	0.94	0	3.92	3.3	1.3	1.0

Page 2 of 3

Boiler Operating Parameters - Third PCB Run On May 10, 1980

Time	Steam Drum Water Level (Inches)	Flame Temperature (^oF)	Back Wall Temperature (^oF)	Oil Flow-Ultrasonic (GPM)	Wind Speed (MPH)	Wind Direction (Comp. Pt.)
Acceptable Range	5" of center			(Ref.)		
1400	+1.0	2600	1670	5.50	11	SW
1415	1.0	2550	1500	4.00	10	SW
1430	1.0	2600	1525	3.70	15	SW
1445	1.0	2625	1525	3.30	12	SW
1500	1.0	2625	1525	3.20	12	SW
1515	1.0	2650	1510	2.80	10	SW
1530	1.0	2650	1520	2.30	10	SW
1545	1.0	2640	1520	2.30	10	SW
1600	1.0	2650	1525	1.90	6	SW
1615	1.0	2650	1450	1.10	10	SW
1630	1.0	2650	1530	1.10	6	SW
1645	1.0	2650	1510	0.80	7	S
1700	1.0	2650	1490	0.80	6	S
1715	1.0	2650	1500	0.50	10	S
1730	1.0	2650	1250	0.40	5	S
Average	+1.0	2630	1500	2.25	9	SSW
Range	0	100	420	5.10	10	45°
Std. Dev.	0	29.1	83.8	1.50	2.8	20°

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APPENDIX G

SUMMARY OF WASTE OIL ANALYSIS

Analysis Values requested by both EPA and DNR, unless otherwise noted. N.D. means not detected. N.D./E.S. means not detected by emission spectrographic analysis.

PHYSICAL AND THERMAL PROPERTIES (by Phoenix Chemical)

Ash	0.45%
Calorific Value	18,600 BTU per pound gross 17,495 BTU per pound net
Carbon Residue	0.93%
Flash Point	345°F
Fire Point (EPA only)	400°F (by Chevrolet)
Sediment and Water	0.1%
Viscosity (Saybolt@100°F) (EPA only)	175 seconds (by Chevrolet)

NON METALLICS AND INORGANICS (by Phoenix Chemical)

Carbon	82.62%
Chlorine	0.97%
Cyanide (DNR only)	N.D.@0.5 ppm (by Chevrolet)
Hydrogen	12.11%
Hypochlorite (DNR only)	(Rapid oxidation of this chemical preclude presence in this oil.)
Nitrogen (DNR only)	0.28%
Sulfur	0.98%

METALLICS REQUESTED (by Phoenix Chemical)

Arsenic	N.D./E.S. (N.D.@0.5ppm by Chevrolet)
Barium (EPA only)	N.D./E.S.
Cadmium (EPA only)	N.D./E.S.
Chromium	8.8 ppm
Cobalt (DNR only)	N.D./E.S.
Copper (DNR only)	12.6 ppm
Lead	23.5 ppm
Mercury	N.D./E.S. (N.D.@0.04ppm by Chevrolet)
Nickel (DNR only)	N.D./E.S. (7 ppm by Chevrolet)
Selenium	N.D./E.S. (N.D.@0.5ppm by Chevrolet)
Zinc	Trace (40ppm by Chevrolet)

OTHER METALLICS (by Phoenix Chemical)

Aluminum	120 ppm
Iron	43.2 ppm
Magnesium	31 ppm
Silicon	0.08%
Sodium	254 ppm
Titanium	23.5 ppm

Summary of Waste Oil Analysis (cont'd.)
Page 2

ORGANICS (by Trace Elements, except as noted)

Aniline (DNR only)	N.D. @ 100 ppm
P Chloro M Cresol	100 ppm
Dichlorophenol	45 ppm
Chlorophenols (DNR only)	145 ppm (total)
Chlorinated Dibenzofurans	N.D. @ 20 ppm (by GCA)
Dibenzofurans	N.D. @ 20 ppm (by GCA)
Dioxin	N.D. @ 20 ppm (by GCA)
Phenols	478 ppm (by Chevrolet)
Polychlorinated Biphenyls	(See Note Below)
Tri N Cresol Phosphate	70,920 ppm
Tri Phenol Phosphate	9,450 ppm
Tri Cresol Phosphate	450 ppm
Triaryl Phosphate Ester (DNR only)	80,820 ppm (8.1%) (total)

NOTE ON ANALYSIS FOR POLYCHLORINATED BIPHENYLS

The waste (reclaim) oil to be used contains 132.5 ppm PCB. For the verification-burn the waste oil will be spiked to approximately 500 ppm PCB. In order to detect the presence of any Chlorinated Dibenzofurans, Dibenzofurans, or Dioxins present in the spiking fluid, the waste oil sample was also spiked with the same fluid. The PCB content of the spiked sample was 598 ppm. The amount of spike fluid added to the waste oil for the verification-burn will be adjusted accordingly so that the concentration is near, but less than, 500 ppm. The actual PCB content of the spiked waste oil for the verification-burn will be reported when available.

SUMMARY OF WASTE OIL ANALYSIS

Laboratories Providing Analysis

Phoenix Chemical Laboratory
3953 West Shakespeare Avenue
Chicago, Illinois 60647

GCA/Technology Division
GCA Corporation
Burlington Road
Bedford, Massachusetts 01730

Trace Elements Laboratories
460 South Northwest Highway
Park Ridge, Illinois 60068

Chevrolet Laboratories
Chevrolet Motor Division
General Motors Corporation
30007 Van Dyke
Warren, Michigan 48090

APPENDIX H

TRACE ELEMENTS INC.
WASTE OIL ANALYSIS METHODOLOGY

(Retyped because copy illegible)

July 29, 1980

Mr. Al Garwick
Chevrolet Motor Division
100 Fitzgerald Street
Bay City, Michigan 48706

Dear Mr. Garwick:

The following is the information you requested per report #6225 of April 1980:

Sample Preparation:

Five milliliters of sample were diluted to 1 liter in water. One such sample was made acidic with 1 + 1 HCl and extracted three times with CH_2Cl_2. The first extraction was done with 100 mol CH_2Cl_2 and the second and third with 50 ml CH_2Cl_2. Due to the nature of the extract (suspected to be highly concentrated), a Kürderna-Danish concentration was not performed on the extract.

A second extraction was performed with 85%/15% hexane/CH_2Cl_2 on a neutral sample. The extracts were again not concentrated by Kürderna-Danish.

Both samples were run GC-MS.

Instrumentation:

GC-MS: Hewlett Packard 5990A
Columns: OV17 10m Capillary
Tenax GC 6' packed

Conditions: Injector 250°C
Injection amount 2 µl
Program: 40°/4 min, 8°/min → 250°

Results:

Acid Extraction:

Dichlorophenol

ρ chloro m cresol

Neutral Extraction

- PCB
- tri m cresol phosphate
- tri phenyl phosphate
- tri cresyl phosphate

Quality Control

A phenol standard, PCB standard, and phosphate pesticide standard were all run prior to the samples to determine instrument sensitivity and proper temperature program for good retention times and resolution. Standards are also run daily for instrument tune-up.

I hope this information is what is needed.

Thank you for doing business with TEI. We hope to continue working with you in the future.

Sincerely,

TEI ANALYTICAL

Susan Krejci

SK/as

APPENDIX I

PHOENIX CHEMICAL LABORATORY, INC.
RECLAIM OIL ANALYSIS RESULTS

TELEPHONE 772 - 3577

Appendix 3 R

Phoenix Chemical Laboratory, Inc.
FUEL AND LUBRICANT TECHNOLOGISTS
3953 SHAKESPEARE AVENUE
CHICAGO, ILL. 60647

August 15, 1980

RECEIVED FROM	Chevrolet Motor Division General Motors Corporation Bay City Plant 100 Fitzgerald St. Bay City, Mich. 48706
SAMPLE OF	
MARKED	Reclaimed Oil 3-26-80

LABORATORY NO. 0 3 28 18

Nitrogen, % ASTM D3228	0.28
Sulfur, % ASTM D129	0.98
Chlorine, % ASTM D808	0.97
Carbon, %) Pregl	82.62
Hydrogen, %) Pregl	12.11
Ash, % ASTM D482	0.45
Water by Distillation, % ASTM D95	Trace
Sediment, mg/100 ml ASTM F312	62,000
Heat of Combustion, BTU/lb. ASTM D240	
Gross	18,600
Net	17,495
Conradson Carbon Residue, % ASTM D189	0.93
Flash Point (COC), F ASTM D92	345
Sodium, ppm)	254
Aluminum, ppm)	120
Iron, ppm)	43.2
Magnesium, ppm) Atomic Absorption	31.0
Lead, ppm)	23.5
Titanium, ppm)	23.5
Copper, ppm)	12.6
Chromium, ppm)	8.8
Silica, % (see 2nd sheet)	0.18

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TELEPHONE 772 - 3577

Phoenix Chemical Laboratory, Inc.
FUEL AND LUBRICANT TECHNOLOGISTS
3953 SHAKESPEARE AVENUE
CHICAGO, ILL. 60647

August 15, 1980

RECEIVED FROM Chevrolet Motor Division

SAMPLE OF

LABORATORY NO 0 3 28 18

MARKED

Silica is determined by ashing the sample, extracting with hydrochloric acid and treating the insolubles with sulfuric acid and hydrofluoric acid. The volatiles liberated by hydrofluoric acid are calculated as silica.

Emission Spectrographic Analysis (Jarrell-Ash instrument)

Major: Sodium, Phosphorus, Silicon

Minor: Aluminum, Iron, Lead, Chromium, Copper, Magnesium, Titanium

Trace: Boron, Calcium, Potassium, Manganese, Molybdenum, Nitrogen, Tin, Vanadium, Zinc

G. A. Krawetz

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APPENDIX J

GM BREATHING ZONE AND POWERHOUSE MONITORING RESULTS

Chevrolet Motor Division
Bay City, Michigan

May 5-10, 1980

Results of Tests for Polychlorinated Biphenyls (PCB's)

Test No.	Location and Description	Sampling Time (minutes)	PCB's (mg/m³)*
	MIOSHA Permissible Exposure Limit		1
	Tests 1-12 were made during the background burn on May 5, 1980.		
1	Breathing zone (BZ) of D. Mika (374-42-7560). Operator, boiler No. 3, afternoon shift.	163	ND**
2	Repetition of Test 1.	156	ND
3	BZ of J. Wiznerowicz (379-34-4679). Operator, boiler No. 3, afternoon shift.	164	ND
4	Repetition of Test 3.	154	ND
5	General condition (GC) test made approximately 5 feet west of boiler No. 3 exhaust stack, second floor.	160	ND
6	Repetition of Test 5.	153	ND

---

*mg/m³ = milligrams per cubic meter of air.
**ND = none detected

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PAGE NUMBER
EPA-287 (Cin.) (4-76)

Results of Tests for Polychlorinated Biphenyls (PCB's)

Test No.	Location and Description	Sampling Time (minutes)	PCB's (mg/m^3)
7	GC test made atop boiler No. 3 control panel, first floor.	156	ND
8	Repetition of Test 7.	153	ND
9	GC test made simultaneously with Test 5 near boiler No. 3 exhaust stack.	156	ND
10	GC test made simultaneously with Test 6 near boiler No. 3 exhaust stack.	153	ND
11	GC test made simultaneously with Test 7 atop boiler No. 3 control panel.	156	ND
12	GC test made simultaneously with Test 8, atop boiler No. 3 control panel.	153	ND
	Tests 13-22 were made during the first day of the PCB burn on May 8, 1980.		
13	BZ of J. Fryzel (369-18-1522). Operator, boiler No. 3, afternoon shift.	174	ND
14	Repetition of Test 13.	175	ND
15	BZ of D. Mika, operator boiler No. 3, afternoon shift.	179	ND
16	Repetition of Test 15.	175	ND
17	GC test made atop boiler No. 3 control panel.	190	ND

Results of Tests for Polychlorinated Biphenyls (PCB's)

Test No.	Location and Description	Sampling Time (minutes)	PCB's (mg/m^3)
18	Repetition of Test 17.	162	ND
19	GC test made simultaneously with Tests 7 and 18.	340	ND
20	GC test made near boiler No. 3 exhaust stack.	186	ND
21	Repetition of Test 20.	153	ND
22	GC test made simultaneously with Tests 20 and 21.	339	ND
	Tests 23-32 were made during the second day of the PCB burn on May 9, 1980.		
23	BZ of E. Markiecki (375-14-7126). Operator, boiler No. 3, afternoon shift.	153	ND
24	Repetition of Test 23.	183	ND
25	BZ of J. Fryzel. Operator, boiler No. 3, afternoon shift.	152	ND
26	Repetition of Test 25.	172	ND
27	GC test made atop boiler No. 3 control panel.	150	ND
28	Repetition of Test 27.	180	ND
29	GC test made simultaneously with Tests 27 and 28.	332	ND
30	GC test made near boiler No. 3 exhaust stack.	152	ND
31	Repetition of Test 30.	180	ND

Results of Tests for Polychlorinated Biphenyls (PCB's)

Test No.	Location and Description	Sampling Time (minutes)	PCB's (mg/m^3)
32	GC test made simultaneously with Tests 30 and 31.	332	ND
	Tests 33-42 were made on the third day of the PCB burn on May 10, 1980.		
33	BZ of J. Fryzel. Operator, boiler No. 3, afternoon shift.	185	ND
34	Repetition of Test 33.	105	ND
35	BZ of D. Mika. Operator, boiler No. 3, afternoon shift.	184	ND
36	Repetition of Test 35.	102	ND
37	GC test made atop boiler No. 3 control panel.	183	ND
38	Repetition of Test 37.	104	ND
39	GC test made simultaneously with Tests 37 and 38.	286	ND
40	GC test made near boiler No. 3 exhaust stack.	181	ND
41	Repetition of Test 40.	101	ND
42	GC test made simultaneously with Tests 40 and 41.	282	ND

WBK:sz

APPENDIX K

GM BOILER RESIDUE ANALYSIS

BOILER PCB RESIDUAL ANALYSIS

Scraping Number	Location	Date	Aroclor 1242 Concentration (PPb)	Aroclor 1242 Sensitivity (PPb)	Aroclor 1254 Concentration (PPb)	Aroclor 1254 Sensitivity (PPb)
Pre-PCB Burn Analysis						
1	Stack #1	10/15/79	ND	47	ND	51
2	Preheater Air Outlet	"	ND	126	ND	137
3	Preheater Air Inlet	"	ND	448	ND	486
4	Furnace North Wall #1	"	ND	55	ND	59
5	Furnace South Wall #1	"	ND	61	ND	66
6	Furnace Floor-Center	"	ND	26	ND	28
7	Furnace Floor-Rear	"	ND	20	ND	21
8	Furnace Rear Wall	"	ND	48	ND	52
11	Preheater Hot Gas Inlet	4/18/80	ND	7	15	7
12	Furnace North Wall #2	"	ND	8	ND	9
13	Furnace South Wall #2	"	ND	9	ND	9
14	Stack #2	"	ND	8	ND	9
Post PCB Burn Analysis						
1	Burner Tips	5/15/80	773	187	413	203
2	Preheater Air Inlet	"	ND	24	ND	26
3	Furnace Floor-Center	"	ND	25	54	27
4	Furnace Floor-Rear	"	ND	9	12	9
5	Furnace Rear Wall	"	ND	20	49	22
6	Preheater Hot Gas Inlet	"	ND	12	20	13
7	Stack	"	ND	11	17	12
8	Preheater Hot Gas Outlet	"	ND	10	ND	11
9	Furnace North Wall	"	ND	10	ND	11
10	Furnace South Wall	"	ND	18	27	20

ND - Non-Detectable

APPENDIX L

GM BLOOD CHEMISTRY RESULTS
(Retyped because copy illegible)

To	Powerhouse Operators	Location	Bay City
From	Dr. Thomas A. Hockman	Location	Bay City
Subject		Date	July 11, 1980

I have received and reviewed the PCB blood level reports on the samples drawn after the test burn.

We can say the following:

1. The range of results before the burn was 7 to 36 parts per billion.
2. The range after the burn is 5.4 to 40 parts per billion.

CONCLUSION: This is About as Close to Identical as Analytical Data Can Get.

3. The average (or mean) before the burn was 18.0 parts per billion.
4. The average after burn is 18.6.

CONCLUSION: No Change

5. In comparison, 39 people who work in the office and presumably have no work association with PCB show that:
    - A) Those who eat in excess of 8 oz of Great Lakes fish per week have a range of 4 to 71 parts per billion and an average of 23.5 parts per billion.
    - B) Those who average less than 8 oz of Great Lakes fish per week have a range of 3.4 tc 50.3 parts per billion and an average of 18.03 parts per billion.

CONCLUSION: The Powerhouse Employes Show Blood Levels Comparable to Those Office Employees With the Least Exposure to Environmental PCB.

And Those Individuals With the Highest Blood Levels in any of the Groups Analyzed Remain Low Relative to Danger Levels and to State-wide Levels.

Any participants in the above sampling program who wish to review their individual reports are welcome to consult with me. Call Ext. 392 for an appointment.

Thomas A. Hockman
Medical Director

TAH:T

APPENDIX M

GCA FIELD CALIBRATIONS

Continuous Monitor Data - corrected 15 minute averages.

Strip chart measurements were reduced and digitized to 15 minute averages and corrected for calibration drift using the following procedure:

Theory:

Instruments calibrations are applied to digitized strip chart data in the following manner.

Given:

On date (D1) in hour (H1) the recorder open measured ZERO1 (ZCR1) chart units when the input of zero ppm (ZEU1) was applied to the instrument. The recorder pen also measured SPAN1 (SCR1) chart units when the input of SPAN1 (SEU1) ppm was applied to the instrument. On a later date (D2) in hour (H2) the recorder pen measured ZERO (ZCR2) chart units when an input of zero ppm (ZEU2) was applied to the instrument. The recorder pen also measured SPAN2 (SCR2) chart units when an input of SPAN2 (SEU2) ppm was applied to the instrument. On an arbitrary date (D) at some time (T) the recorder pen measured CV chart units.

Find:

The actual value on date D at time T in ppm.

Assumption 1: The base line (zero) of the recorder drifts linearly between measurements of the zero.

The zero (Z) at time T on date D is therefore

$$Z = ZCR1 + (T-H1) * (ZCR2-ZCR1)/(H2-H1) \qquad (1)$$

Assumption 2: The chart scale (ppm/chart unit) of the recorder drifts linearly between measurements of the span.

The scale factor (SF1) on DATE1 at HOUR1 is

$$\mathrm{SF1} = (\mathrm{SEU1}-\mathrm{ZEU1})/(\mathrm{SCR1}-\mathrm{ZCR1})$$

The scale factor on DATE2 and HOUR2 is

$$\mathrm{SF2} = (\mathrm{SEU2}-\mathrm{ZEU2})/(\mathrm{SCR2}/\mathrm{ZCR2})$$

The chart scale factor on date D at time T is therefore

$$\mathrm{SF} = \mathrm{SF1} + (T-\mathrm{H1}) * (\mathrm{SF2}-\mathrm{SF1})/(\mathrm{H2}-\mathrm{H1}) \qquad (2)$$

Applying equations (1) and (2) to the chart value CV on date D at time T we find

$$\text{Actual Value} = \mathrm{ZEU} + (\mathrm{CV}-Z) * \mathrm{SF}\ (\mathrm{ppm})$$

Stack Data Reduction

Source sampling data reduction sheets for the PCB and Modified Method 5 (organic) sampling trains have been retained by the contractor for this project, under Contract 68-02-3168, Work Assignment No. 9. Copies of these sheets may be obtained by contacting GCA/Technology Division.

APPENDIX N

DISCUSSION OF RECLAIM OIL DATA

GCA

GCA CORPORATION
Technology Division
213 Burlington Road
Bedford, Massachusetts 01730
(617) 275-5444
Telex 923339

August 8, 1980

Mr. Peter Collins
RTI
P.O. Box 12194
Research Triangle Park, NC 27709

Dear Mr. Collins:

Enclosed are the GCA/Technology procedures for PCB in Fuel Analysis used for the GM PCB verification burn. The procedures document sampling, chain-of-custody, analysis, and quality control.

Please call me at (617)-275-5444 if you have any further questions.

Sincerely,

Joanna M. Hall

Joanna M. Hall
Laboratory Analysis Department

JMH:vmk
Enclosures

cc: K.T. McGregor (w/o enclosures)
    G.T. Hunt (w/enclosures)
    R.M. Ellersick (w/enclosures)
    D. Sanchez (w/enclosures)

ANALYSIS OF FUEL OIL FOR PCB

Sampling Procedures

Fuel and waste oils were sampled at the GM-Bay City plant as part of the PCB verification burn program. The oil sampling was performed by GM personnel and the samples shipped to GCA for analysis. Each sample was provided in a glass container which had been rigorously cleaned using the following sequence: acid soak, alcoholic KOH soak, distilled deionized water rinse, acetone rinse, and hexane rinse. As a further precaution container caps were lined with Teflon.

Sample Traceability

Samples were received at the GCA facility by the Sample Bank Manager where sample conditions and identification codes were recorded prior to its distribution for analysis. All transfers of the samples followed prescribed chain-of-custody procedures. All subsequent handling of each sample was recorded in the sample bank master log accompanied by appropriate signatures and dates of transfer. At the conclusion of the prescribed analysis sequence the remainder of each sample was returned to the sample bank. (See attachments for excerpts from GCA/Technology Quality Control Manual).

Analysis Procedure

Fuel oil sample bottles were heated to 40°C in a water bath and stirred for 1 minute prior to aliquotting to ensure sample homogeneity.

A 0.5 g portion of each sample was transferred to a clean, pre-tared 5.0 ml volumetric flask. The flask was reweighed and the sample diluted to 5.0 ml. The well-mixed sample was removed to a clean, 10 ml vial containing 5.0 ml of concentrated sulfuric acid for cleanup per the procedure cited in the Federal Register, May 31, 1979 (40 CFR 761-31538). The oil/acid phases were mixed and the oil fraction quantitatively transferred to a clean vial containing 5.0 ml of 10 percent $NaHCO_3$ (aq). A portion of the oil fraction was then transferred to a septum vial for gas chromatographic analysis.

Instrument operating parameters were as follows:

Instrument: Hewlett-Packard Model 5840 Gas Chromatograph, equipped with an Electron Capture Detector (ECD) and Model 7671A Automatic Liquid Sampler.

Column: 6 ft x 2 mm pyrex, packed with 1.5 percent OV-17/1.95 percent QF-1 on 100/120 mesh Chromsorb WHP.

Temperatures (°C): Column = 175
Inlet = 270
Detector = 300

Gas Flow: 50 cc/min 5 percent methane in argon

Area Rejection: 1000 area counts

Slope Sensitivity: 0.18

Instrument calibration was accomplished by injection of 1.0, 2.0 and 10.0 ppm (μg/ml) dilutions of an Aroclor 1242 standard prepared in hexane. These dilutions were prepared from a commercially available stock solution distributed by Applied Science Labs, Inc., State College, Pa. Calibration was checked every sixth sample to ensure a uniform detector response. A typical Aroclor 1242 standard chromatogram is attached noting retention time of the five peaks where areas were summed in obtaining each of the three calibration points (2.90, 3.96, 5.21, 6.74, and 9.85 min.).

Calibration curves were prepared daily from a linear regression analyses of the above three Aroclor dilutions. Each of these data points was obtained from a sum of the five appropriate areas.

Calibration curves were rejected if the correlation coefficient of the linear regression analyses was less than 0.996. All samples were quantitated by entering the area summation into the appropriate calibration curve. Sample extracts were diluted, if necessary, to be within the concentrations bracketed by the calibration standards.

Results

Quantitative Aroclor 1242 measurements on each of the verification burn oil samples are shown in the following Table. Each was calculated from the Applied Science curve per the calibration procedure described earlier:

Sample ID	µg/g
Day 1 fuel feed	<1.2
Day 2 fuel feed	72
Day 3 fuel feed	76
Day 4 fuel feed	88
Reclaim waste oil	750

Quality Control

Three 0.5 gm aliquots of No. 6 fuel oil were spiked by the addition of 25 µl of a 1.0 µg/µl solution of Aroclor 1242 in iso-octane (Applied Science). As a means of method verification, samples were processed as described above. The results of these analyses are summarized in the following Table:

QUALITY CONTROL - PCBs/FUEL OIL

Sample	µg Added	µg Observed	% Recovery
A	25	24	96
B	25	24	96
C	25	23	92
$\bar{X}$	25	24	96
S_x	-	0.58	-

Aroclor 1242 reference materials (Lots No. 8758 and No. 8937) were obtained from the Reference Standards Repository, Environmental Toxicology Division, EPA Health Effects Research Laboratory, Research Triangle Park, North Carolina.

Dilution of the above materials were prepared by the laboratory quality control coordinator and submitted as "blind" checks on the preexisting calibration curves constructed from each of two commercially available Aroclor 1242 stock solutions.

The initial calibration curve had been prepared from dilution of an Aroclor 1242 stock solution provided by Supelco, Inc. of Belleforte, Pa. The observed concentration for each of the "blind" checks as calculated from this calibration mixture are shown in the following Table:

RTP AROCLOR 1242

Lot No.	Nominal concentration (μg/ml)	Concentration observed (μg/ml)
8758	34	22
8937	6.7	4.3
(using Supelco calibration)		

Further inquiry included conversations with appropriate personnel at Supelco. To their knowledge there was no justifiable evidence that their stock solution was responsible for the observed concentration discrepancy.

However, when the same two "blind" checks were quantitated from the Applied Science calibration mixtures the results were as follows:

Lot No.	Nominal concentration (μg/ml)	Concentration observed (μg/ml)
8758	34	34
8937	6.7	6.7
(using Applied Science calibration)		

As a further means of verification, quality control check samples procured from EPA/EMSL (Cincinnati, Ohio) were submitted for analysis. The results for these Aroclor 1242 QC mixtures as derived from the same Applied Science calibration mixture were the following:

Nominal concentration (μg/ml)	Mean concentration observed (duplicate analyses) (μg/ml
6.3	8.4
6.3	8.6
1.9	2.3

1.2.8 SAMPLE ANALYSIS

The GCA/Technology Division performs a wide variety of programs requiring reliable chemical analyses. The Technology Division Analytical Laboratory performs the bulk of these analyses but field measurements and certain other air pollution analyses are handled by the Environmental Measurements Department. Both groups strive to include all elements of quality assurance in their programs.

1.2.8.1 Analytical Laboratory Quality Control

The Analytical QC Manual documents procedures in use which are implemented by the entire laboratory staff with direction from the Analytical QC Committee and the QA Manager. The Analytical QC Committee consists of the Sample Bank Manager, an analyst responsible for implementing inorganic analytical QC and one responsible for organic QC. These committee members are appointed by the Laboratory Manager and report to him and to the division QA Manaber. The Committee works closely with the QA Manager and the chairman serves on the division QA/QC Committee.

1.2.8.2 Field Measurements Quality Control

Environmental Measurements Department staff members with expertise in ambient, fugitive and source emission measurements serve on the department QA/QC Committee and ensure that all staff members are following appropriate quality control procedures. The Sampling and Field Measurements QC Manual includes checklists for field instrumentation.

1.2.8,3 Specialized Analyses/QA Project Plan

If a project requires analytical work that will be done by other than GCA laboratory staff, the QA Project Plan will outline the quality control procedures for analysis. An example is the Asbestos Measurement program which requires skilled geologists or mineralogists to perform the analyses. Environmental Engineering Department staff with the necessary expertise identify and characterize the asbestos and use the appropriate QC procedures.

1.2.7.3 Sample Bank/Chain of Custody

The chain of custody for field measurements is maintained by the ambient site log or the source measurement project log book. Sample recovery and integrity forms are used to identify the person responsible for the sample at all times from collection to final measurement or analysis.

All samples submitted to GCA/Technology Division laboratories are brought to the Sample Bank Manager who establishes a chain of custody by assigning a GCA Control Number to each sample on receipt which identifies it through all further handling. The sample is recorded in the Master Sample Log under this number and the QA Project Plan is consulted for preservation and storage requirements. Technology Division maintains large, locked, refrigerated and nonrefrigerated storage areas with provision for hazardous material storage. After necessary preservation or subdivision, the Sample Bank Manager stores each sample in the appropriate area, filed under its GCA Control Number. Samples which will not be analyzed by GCA's Laboratory Analysis Department are handled in essentially the same way with the Project Manager responsible for notifying the Sample Bank Manager of receipt of samples.

The chain of custody for information gathering projects is outlined in the QA Project Plan. Accurate recordkeeping is essential and should include a log of the numbered survey forms which can follow each form through computerized data handling and storage.

APPENDIX O

LOG OF SIGNIFICANT ACTIONS

LOG OF SIGNIFICANT ACTIONS

Time	Action
Background Run on May 5, 1980:	
1510	Initiated burn and monitoring.
2025	Terminated burn and monitoring.
First PCB Run on May 8, 1980:	
1350	Initiated burn and monitoring.
1945	Terminated burn and monitoring.
Second PCB Run on May 9, 1980:	
1258	Initiated burn and monitoring.
1535	Observed low flame and backwall temperatures. Switched to No. 6 fuel oil supply system.
1542	Observed acceptable temperatures. Switched to reclaim oil supply system.
1815	Terminated burn and monitoring.
Third PCB Run on May 10, 1980:	
1400	Initiated burn and monitoring.
1738	Reclaim oil supply system pump inadvertantly stopped. Oil pressure and flow dropped. Pump immediately restarted. Oil flow would not increase above 1.6 gpm.
1739	Switched to No. 6 fuel oil supply system. Attempted to regain 4 gpm oil flow.
1750	Switched to No. 2 fuel oil supply system. Attempted to regain 4 gpm oil flow.
1840	Unable to regain 4 gpm oil flow. Terminated burn and monitoring.
1845	Secured boiler.

APPENDIX P

PCB WASTE OIL SUPPLY SYSTEM OPERATIONAL PROBLEM

The supply system used for the PCB waste oil during the verification burn was assembled primarily from components that were available on-site. Due to its limited application and expected service life, this system was not as sophisticated as the permanent oil supply system for No. 6 fuel oil. The PCB waste oil supply system did not have the filtration equipment, continuous bypassing piping, nor degree of delivery pressure control that the permanent oil supply system has.

Because of these limitations, maintaining a constant flow from the waste oil to the boiler was a problem during all three PCB runs. Flow rate irregularities, in the form of abrupt changes (spikes) occurred frequently and unexpectedly throughout the runs. However, through continuous monitoring and manual adjustment, we were able to control the amplitude and duration of the spikes and maintain an adequate flow rate in such a manner that the other key parameters remained at acceptable levels.

Two revisions should be made to the waste oil supply system to improve its performance. The first revision should correct the oil-related problems experienced during the verification burn due to the absence of filtration of the No. 6 fuel oil. Rather than delivering the No. 6 fuel oil directly to the waste oil supply tank from a tanker truck, the No. 6 fuel oil should be pumped from an existing No. 6 fuel oil bulk storage tank through the existing No. 6 fuel oil filtration equipment to the waste oil supply tank. The second revision should correct equipment-related pressure control problems of the system. A waste oil supply system return line should be provided from the boiler to the waste oil supply tank to provide an alternate (loop) path for excess oil flow to eliminate "dead ending" pressure fluctuations.

APPENDIX Q

PREMATURE TERMINATION OF THIRD PCB RUN

The third PCB run was terminated prematurely due to a malfunction within the waste oil supply system. While attempting to compensate for a fuel flow spike, the boiler operator inadvertently turned off the waste oil supply pump. Both the waste oil supply pressure and the waste oil flow rate dropped significantly. However, the pump was restarted quickly so that the burner flames were not lost. Upon restarting of the supply pump and re-establishment of supply oil pressure, neither the oil pressure at the burners nor the oil flow rate could be increased to their prior levels.

Because the required conditions of the verification burn were not being met, the boiler was switched to No. 6 fuel oil in accordance with established safety and permit procedures. Oil pressure and flow rate were not improved by the switch. The observed gauge readings and the boiler's reaction to the control adjustments that were made indicated the presence of a partial blockage upstream of the burners in the piping which is common to the three oil supply systems for this boiler. The boiler was then switched to the No. 2 fuel oil system in an attempt to dissolve or to dislodge the suspected blockage with the lighter fuel oil. This action also had no effect on either pressure to the burners or flow rate. Having exhausted all available alternatives, the burn was terminated, and the boiler was shut down.

The available evidence indicates that a partial blockage occurred in the boiler oil flowmeter. This device operates on a piston and port principle, and a high viscosity substance could restrict piston movement and/or reduce the effective port area of the meter. This type of failure would account for the reduced oil pressure and flow rate which were observed. Blockages at other possible locations in the system would produce different observed conditions.

The boiler operating parameters monitored during the third PCB run indicate that a progressive restricting action within the port area of the meter was indeed occurring during that entire run. Each of the parameters which were dependent on oil flow rate had steadily decreased from the initiation of the run until the malfunction occurred. Actual oil flow was apparently dropping due to the smaller and smaller effective port areas, even though the flow meter was showing a constant flow rate due to a "sticking" condition.

In support of this reduced oil flow rate during the third PCB run, key boiler parameters were analyzed and compared with the other three runs. Air heater temperature-air in, flue gas opacity, fuel oil temperature, steam drum water level, and flame temperature were found to be independent of fuel oil flow rate within the range of concern. Air heater temperature-air out, air heater temperature-gas in, air heater temperature-gas out, windbox pressure, furnace pressure, air heater pressure in, and air heater pressure out were found to be related to fuel oil flow rate within this range, but provided inconsistent results. Fuel oil pressure, steam flow rate, atomizing steam pressure, and backwall temperature were found to be proportional to fuel oil flow rate within the range of concern, and were used to determine that, in fact, an average fuel oil flow rate of 3.2 instead of 4.0 gallons per minute was occurring during the third PCB run, as summarzied below.

Parameter Examined	Average at 4 gpm	Average for Third PCB Run	Adjusted gpm Third PCB Run
Fuel Oil Pressure	38 psig	31 psig	3.3 gpm
Steam Flow Rate	39 Mlb/hr	32 Mlb/hr	3.2 gpm
Atomizing Steam Pressure	48 psig	39 psig	3.3 gpm
Backwall Temperature	1,670°F	1,500°F	3.1 gpm
	Average Fuel Oil Flow Rate		3.2 gpm

After the termination of the third PCB run, the meter was disassembled. After cleaning and reassembly of the meter, the problem was eliminated and it has not reappeared during several subsequent firings of the boiler using No. 6 fuel oil and the primary oil supply system.

APPENDIX R

DATA INTERPRETATION

DESTRUCTION EFFICIENCY

A primary objective of this program was to document the PCB destruction efficiency for a high efficiency oil-fired industrial boiler. To make this determination statistically valid, 3 days of test data were required, as well as a measurement of variability between test days. Unfortunately, test results for the third burn day are lost. Further, there were no measurable PCB concentrations from which to determine variability on each of the remaining 2 days. Therefore, the planned statistical tests could not be meaningfully applied to the test data.

The probability of the achievement of greater than 99.9 percent destruction cannot be assigned a statistical value. However, the measurement of 2 days of greater than 99.994 percent destruction efficiency strongly indicates the high probability of that achievement.

A more detailed description of the statistical methods used is available in the PCB burn test plan.[4]

Statistical Test

On each day there were three samples available at each onsite monitor (one obtained during boiler test, one obtained before, and one after). An appropriate statistical test for testing the null hypothesis of the equality of PCB levels at the three monitors (i.e., no plant contribution) versus the alternative hypothesis of differences between the background station and the other two stations (i.e., plant adds to PCB levels) is a paired t test. Let A_i, B_i, and C_i represent the PCB levels at Stations A, B, and C for times 1, 2, and 3, then the t statistic of this t test is:

$$t = \frac{\sqrt{3}\,\overline{D}}{S_D}$$

where

$$\overline{D} = \frac{\sum_{i=1}^{3} D_i}{3}$$

and

$$S_D^{\,2} = \frac{\sum_{i=1}^{3} \left(D_i - \bar{D} \right)^2}{2}$$

with

$$D_i = \frac{B_i + C_i}{2} - A_i$$

for i = 1, 2, and 3. The power of the test (i.e., probability of rejecting incorrect null hypothesis) depends upon the level of significance and the true value of k. If we view the t test as a one-sided test with level of significance of 0.05, then some estimated maximum power values for various k values are:

k	Estimated maximum power
1	0.20
1.5	0.40
2	0.45
3	0.50
4	0.55
6	0.60

Using the measured ambient PCB concentrations listed in Table 5, the t statistic results are summarized in Table R-1.

For this evaluation H_o is accepted if t-test (see Table R-1) is less than $t_{0.05}(2) = 4.303$ and H_1 is accepted if t-test is greater than $t_{0.05}(2) = 4.303$. Acceptance of H_o shows no plant contribution whereas H_1 shows significant contribution.

Days 1 and 4 show no significant plant contribution to ambient PCB levels (H_o). Days 2 and 3 do show significant difference between the upwind and downwind sites in measured PCB concentration (H_1). The significant values are not in concert with the original hypothesis, that PCB levels have added to background levels, therefore, concluding that there has been no apparent increase in PCB levels due to the burn.

Population Exposure--

To measure the impact of the PCBs from the plant on human population, a fourth monitor was placed in a nearby population center located downwind.

TABLE R-1. t-TEST FOR UPWIND VERSUS DOWNWIND SITES

Time period	Day 1		Day 2		Day 3		Day 4	
	$\frac{B_i+C_i}{2}$	A_i	$\frac{B_i+C_i}{2}$	A_i	$\frac{B_i+C_i}{2}$	A_i	$\frac{B_i+C_i}{2}$	A_i
Preburn	950	190	127	350	30	390	43.5	120
Burn	360	190	83	350	50	390	78	120
Post-burn	32.5	190	127.5	350	19	390	-	120
Critical value[15] of student's t distribution	$t_{0.0}5^{(2)}=4.303$		$t_{0.05}^{(2)}=4.303$		$t_{0.05}^{(2)}=4.303$		$t_{0.05}^{(1)}=12.706$	
t Test	0.959		-16.10		-39.34		-3.43	

Where A is upwind - Site 1; B is downwind - Site 2; C is downwind - Site 3.

For the t-test on population exposure F = the population station and A = the upwind station, F and B represent the PCB levels at Stations F and A for days 1, 2, 3, and 4.

The t statistic for this t-test is:

$$t = \frac{\sqrt{4}\,\overline{D}}{S_D}$$

$$\overline{D} = \frac{\sum_{i=1}^{4} D_i}{4}$$

$$S_D{}^2 = \frac{\sum_{i=1}^{4}\left(D_i - \overline{D}\right)^2}{2}$$

$$D_i = F_i - A_i$$

Using the measured ambient PCB concentrations listed in Table 5, the t statistic results are shown in Table R-2.

TABLE R-2. t-TEST FOR UPWIND VERSUS POPULATION SITES

	F	A
Day 1	63	190
Day 2	67	350
Day 3	28	390
Day 4	51	120
	t = 310	

Where the critical value[12] of student's t distribution is $t_{0.05}(3) = 3.182$.

From the t-test results, H_o is accepted which shows that there is no significant difference in PCB concentration between the upwind and population sites. This conclusion is evident from the values being the opposite of the original hypothesis. Therefore, you can not presume any positive change in PCB concentration in ambient levels as you have mathematically disproved this as being possible.

GLOSSARY

Aroclor 1242: Commercial mixture of PCBs manufactured in the United States by Monsanto. The digits "12" refer to biphenyl as the parent compound; the digits "42" indicate that the chlorine content of Aroclor 1242 is approximately 42 percent by weight. Aroclor 1242 was the PCB mixture burned by General Motors and was the reference standard for PCB measurements.

M-5-1: Three emission test runs conducted to measure hydrogen chloride, dibenzofuran, chlorinated dibenzofurans, chlorinated dioxins and organics released during the PCB burn. M-5-1 was conducted as a background run with no PCB contaminated oil fed to the boiler. M-5-2 and M-5-3 were conducted during the PCB run. Particulate and organic vapors from all three runs was analyzed for the compounds cited.

Modified Method 5 sampling train: The sampling train used for test runs M-5-1 - M-5-3. This train is similar to a standard EPA Method 5 particulate train except for the addition of a temperature controlled adsorbent column of XAD-2 resin between the first and second impingers. This column was used to collect organic emissions. The contents of the 4 glass impingers following the particulate filter are also different from the Method 5 train. (Refer to Section 4).

PCB-1 - PCB-5: Five emission test runs conducted to measure stack gas PCB emissions. PCB-1 was a background run with no PCB contaminated oil fed to the boiler. PCB-5 was intended as a valid test run, but the sample was inadvertently spilled and the emission data was not used. PCB-2,3 and 4 were the three valid test runs used to measure PCB destruction efficiency.

PCB sampling train: The sampling train used for test runs PCB-1 - PCB-5. This train differs from a standard Method 5 train in that (a) there is no particulate filter and (b) a Florisil cartridge is inserted between the third and fourth impingers to collect PCB emissions. (Refer to Section 4).

Spiked waste oil: The PCB contaminated oil used for the GM test burn. As received from GM's wastewater treatment plant, the waste oil contained 132.5 ppm of PCBs. This oil was "spiked" for the destruction efficiency tests by adding Aroclor 1242. Spiking increased the PCB concentration to 500 ppm and thereby improved the accuracy of the PCB destruction efficiency determination. (See Section 3).